DEVELOPING THE NET METERING MARKET IN PAKISTAN

SUSTAINABLE ENERGY FOR PAKISTAN (SEP) PROJECT

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FINAL REPORT

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EXECUTIVE SUMMARY

Pakistan introduced net metering regulations in 2015 (the *"National Electric Power Regulatory Authority Distributed Generation and Net Metering Regulations, 2015"*) to promote power generation from distributed Renewable Energy (RE) systems. The growth in net-metering installations is however slow, with only 815 licenses issued by December 2018, adding 17.28 MW to the country's installed power generation capacity. Considering Pakistan's RE potential, especially from solar PV installations, the slow growth in net-metering is a missed opportunity for the country. In order to develop the net metering market in Pakistan and to accelerate the proliferation of distributed generation (DG) technologies, this report provides an assessment of the regulatory and market barriers that are limiting the effectiveness of Pakistan's net metering program and recommends specific interventions to address these barriers.

Distributed generation produces electricity from small energy systems, at or near the point of consumption and grid-connected distributed generators can be used to offset an electricity customer's energy consumption or provide grid support through peak-shaving, load shifting and ancillary services. Although grid-scale generation has better economies of scale in most regions of the world, at least 63 countries had policies in place by 2017 to support distributed renewable energy generation. Government support for DG in these countries is motivated by the additional benefits that DG systems can potentially deliver to stakeholders (including consumers, distribution companies and transmission network owners) such as mobilizing private finance, reducing transmission investments and distribution losses, providing grid support and addressing land-use constraints where land for grid-scale solar is limited or unavailable.

Driven primarily by public policy and financial incentives, global installed residential and commercial photovoltaic (PV) capacity grew to 173GW in 2017, with Australia, Germany and Japan currently producing more solar energy from DG than centralized, grid-scale solar. Compensation mechanisms including net metering (in the US, Brazil, India and Sri Lanka) and Feed-in-Tariffs (FITs) offered in conjunction with net-billing (in Germany, Italy, Japan, Thailand and Australia) are the most common forms of policy support for grid-connected distributed generation.

GLOBAL LESSONS ON IMPLEMENTING NET-METERING

Traditional net metering allows a consumer's electricity meter to spin backwards, effectively erasing the cost of some of the electricity consumed from the grid. As a compensation mechanism, net-metering is relatively simple to implement for electricity consumers, DISCOs and regulators and delivers benefits to all stakeholders; customers with net metering save on electricity bills, DISCOs benefit from new generation capacity and reduced distribution losses while policy-makers can promote a sustainable source of energy with minimal regulatory change since net-metering is incorporated on top of the existing retail electricity tariffs.

Countries around the world have implemented net-metering programs with varying degrees of success. The effectiveness of net-metering schemes relies on a number of factors, including the design parameters of net metering regulations, the institutional capacity of DISCOs and others involved in implementing the program, the availability of additional incentives and the presence of an enabling market environment. Important lessons from global net metering schemes include:

- Net-metering policies are only effective and economically efficient when designed to cater to the local market environment and implemented through a carefully considered market rollout plan.
- Market conditions should guide the choice of regulation design and the limits applied to each regulatory element. The most important regulatory elements include the metering and billing arrangement, electricity sell-rate design (or the tariff paid for electricity that a net-metered customer supplies to the grid), the overall cap on net metered installations, the system-size

limit on individual installations, a local-level cap based on the capacity of distribution transformers to accommodate DG without adverse impacts on the grid and the credit reconciliation period.

- Distributed generation compensation schemes such as net metering face inherent challenges and usually require supporting incentives to achieve policy objectives. In the past decade, the most widely used supporting incentives were fiscal incentives and public financing through capital subsidies, tax and duty reduction, taxes credits, public loans and grants etc.
- DG compensation schemes can fail to achieve targets if barriers linked to the enabling environment, such as limited access to debt, lack of diversity in business models' institutional capacity issues and technical constraints (availability of transmission infrastructure for instance) are not addressed. The slow growth of grid-connected DG in both China and India highlights the relevance of the enabling environment, particularly in emerging markets.
- Increasing levels of DG on grid-networks produces costs and benefits that impacts energy system stakeholders in different ways; electricity consumers with net metering installations benefit through cost savings on electricity bills however, at higher levels of net metering penetration, electricity customers without net metering assume a larger share of fixed network costs, essentially cross-subsidizing net metered customers. Governments can face a revenue loss from reduced tax collections while transmission and distribution companies face impacts on revenues, network costs and grid stability. Although the negative impacts of DG materialize at relatively high levels of DG uptake, prudent policy practice requires policy makers and regulators to assess the technical and financial impacts of DG on all stakeholders before implementing a DG support policy such as net metering.

NET METERING IN PAKISTAN: SITUATION ANALYSIS

High cost of electricity, excessive system losses and good solar irradiation make the economic case for distributed solar PV in Pakistan. The market for net metering in the country is predominantly urban and caters mostly to demand from the residential segment. However, the levelized cost of electricity (LCOE) for all three market segments (residential, commercial and industrial) is below grid-parity and electricity from rooftop PV is cheaper than much of the current grid-supplied electricity in most parts of the country. The proliferation of DG products and services in the local market is following the pattern of DG growth in other emerging market countries such as Brazil, where incomes, population and electricity tariff levels are the primary determinants of DG technology uptake. Given the current tariff and taxation regime in Pakistan, the commercial segment of the market stands to benefit the most from generating electricity on-site, at a lower cost than grid-supplied power in many cases.

Pakistan's transmission infrastructure is barely adequate to serve the expected load in 2018 and losses on both the transmission and distribution networks are high, leading to excessive wastage and chronic revenue deficits at the DISCOs. The distribution system constraints in fact, represents an opportunity where net metering could potentially alleviate some of the issues in the system operation by reducing distribution losses, decreasing network congestion and providing additional power to eliminate or reduce forced interruptions in electricity supply. Suitably placed net metered systems can also aid voltage regulation on the distribution network, especially in locations where feeders are overloaded.

More than 90% of the equipment used in net metering installations in Pakistan is imported from other countries (predominantly China) with system integration and installation services provided by several small and mid-sized companies known locally as installers, solar companies or solar system providers. At the high-end of the market, these companies offer a full suite of Engineering, Procurement and Construction (EPC) services and post installation operation and maintenance (O&M) support.

Since net-metering regulations in Pakistan allow only 3-phase electricity customers to participate in the net-metering program, the potential market for net-metering is limited to approximately 882, 707 customers, including 371,060 residential, 150,927 commercial and 360,721 industrial electricity consumers, or approximately 3% of all grid-connected electricity customers in the country. Although the potential market is small compared to the grid's customer base, these customers consume approximately 35% of all electricity delivered by the distribution grid and provide more than 40% of all revenues collected by public and private distribution companies.

CURRENT NET METERING SUPPORT PROGRAMS

The Alternative Energy Development Board (AEDB) has implemented several interventions in collaboration with the German development organization (GIZ) and others, to address the barriers limiting net metering proliferation in Pakistan: commissioned by GIZ, **PV Passport** is a certification procedure for PV systems. The project will also organize training seminars for participating commercial banks in Pakistan and is expected to run until September 2019. **Pakistan Distributed Generation Roadmap** is a GIZ study for assessing the technical and financial impact of net metering on the distribution system owned by the Islamabad Electric Supply Company (IESCO). **PV Ecosys** is an online platform that Step Robotics, a Pakistan-based technology startup, is developing for AEDB. The platform is designed to address issues associated with the net metering application and installation process.

KEY ISSUES AND RECOMMENDATIONS

ADDRESS POLICY, LEGAL AND REGULATORY ISSUES

1) *Pakistan's RE policy lapsed in 2018 with no clear indication of whether net metering will receive policy cover under a new policy regime.*

The net metering policy framework should be embedded in a broader policy to encourage the development of renewable energy sources. Given the low cost of energy generated from roof-top solar installations and the rising cost of the tariff subsidy, government funded DG systems could also provide an effective lower-cost alternative to electricity tariff subsidies. A detailed cost-benefit analysis would be required to determine the exact impact of DG and net-metering on low-income, low-use residential electricity consumers and gauge the potential of government funded DG systems to reduce electricity subsidies.

2) *The current net metering regulations do not reflect the changes in the NEPRA Act that could benefit electricity customers with net metering installations.*

Based on the NEPRA Act 2018, net metered installations should be excluded from the mandatory generation license requirement and should not be restricted to sell surplus electricity to their host DISCO only. Cooperative housing societies and consumer associations generating captive power should also be allowed to subscribe to the net metering program.

3) *Net metering regulations are missing local-level caps, include no provisions for information sharing between the DISCOs and the regulator, and allocate all equipment and interconnection costs to consumers.*

NEPRA should specify local caps on net metering, based on the capability of feeding system at the distribution transformer (DT) and distribution-grid level. A system assessment would need to be conducted by the regulator and DISCOs to arrive at a suitable DT level cap**.** DISCOs should provide regular progress reports to NEPRA.

4) *The interconnection standards are ambiguous on several accounts.*

Small, RE-based distributed generators with a capacity of less than 500 kW, connecting to the distribution grid at a voltage lower than 11kV should be included as a separate category in Schedule I of the *Interconnection Regulations, 2015*. Subject to prior assessment of the feasibility of an exemption, the regulator could exempt smaller systems (10 kW or smaller) from simulation studies. Net metered customers connecting to a distribution network should be provided with the required interconnection facility by the host DISCO.

DEVELOP A MARKET ROLL OUT AND IMPLEMENTATION PLAN

1) *There is no clear implementation plan in place to guide market rollout of the net metering program.*

The Ministry of Energy (MOE) should treat net metering as a provisional policy intervention, define clear objectives for the program and provide an implementation plan for market rollout. An upfront review of technical and financial impacts of net metering on distribution companies should be conducted to reduce risks to the distribution companies and investors.

ADDRESS MARKET BARRIERS

1) *High upfront costs and a lack of financing options make net metered systems unaffordable for most electricity consumers.*

Assist financial institutions to develop consumer finance products for the small-scale DG market and improve their institutional capacity to process loans for net metered installations. Involving DISCOs in PPAs between consumers and third-party installers and financing agreements between banks and net metered customers will also improve the flow of financing to the sector.

2) *Distribution companies have limited resources and administrative capacity to effectively manage the net metering program.*

Automate key processes for installing and managing net metered systems (application, interconnection and billing etc.) and train DISCOs to conduct financial and technical impact assessment.

3) *Some distribution companies are reluctant to support the net metering program due to concerns around revenue loss.*

The DISCOs' concerns over revenue loss could be addressed through new business models. For instance, DISCOs can participate in rooftop solar PPAs with third-party installers (by assuming agency for credit collection or providing joint guarantees to financial institutions) or directly provide net metering installation services to their customer base.

4) *The installation process is unnecessarily complex*

To simplify and expedite the process for installing net metered systems, key processes need to be simplified and expedited.

5) *Most consumers are unaware of the benefits of net metering or consider the technology ineffective and unreliable.*

The availability of net metering and risk reducing initiatives by AEDB and others need to be publicized through a targeted consumer awareness campaign.

6) *Rooftop space is not always available or adequate for solar PV installations*.

Commercial net metered customers located in rented spaces or those requiring more space for rooftop generation than available at their own premises should have the option of wheeling electricity from a separate generation location through virtual net metering or meter-aggregation arrangements.

The main barriers curtailing the growth of net metering in Pakistan and recommendations to address the barriers are summarized in the table below. The table also indicates existing interventions by the Alternative Energy Development Board (AEDB) and others to resolve particular issues and proposes SEP activities to either extend existing programs or implement new initiatives.

Table I: Developing the net-metering market in Pakistan: Summary Recommendations

Issue		Recommendations	Key Stakeholders
1	Lack of policy cover	• Include net metering in the new energy policy	MOE, AEDB
2	Inconsistency of the policy with the NEPRA Act 2018	• Exempt net metering installations from generation licenses • Allow sale of surplus electricity to any DISCO • Allow net metering to cooperative housing societies and consumer associations generating captive power	MOE, NEPRA
3	Deficiencies in net metering regulations	• Conduct a system assessment to determine a suitable local-level cap • Assign the upfront cost of bi-directional meters and interconnection to the DISCOs (to be recovered from the net metered consumer through a monthly charge) • Require DISCOs to submit net metering subscription information to regulator on a monthly basis.	NEPRA
4	Deficiencies in Interconnection standards	• Assign a separate category in the Interconnection Regulations to small generators connecting at a low voltage • Clarify responsibility for simulation studies • Assess feasibility of exempting small DG systems (10 kW or smaller) from simulation studies.	NEPRA
5	Lack of a net metering implementation plan	• Apply net-metering as a provisional policy intervention with clear objectives and an implementation plan • Perform an upfront review of technical and financial impacts of net metering on distribution companies • Assess the impacts of net metering on the energy network performance	Ministry of Energy, NEPRA, AEDB, DISCOs
6	High capital cost of system and limited access to debt	• Train financial institutions in processing small RE loans • Develop standardized tools to assess rooftop solar project risk • Involve DISCOs in PPA between consumers and third-party installers	AEDB DISCOs State Bank of Pakistan International Development Organizations Financial Institutions
7	Limited administrative capacity of the distribution companies	• Train DISCOs in process implementation and financial/technical impact assessment • Process automation	AEDB, GIZ DISCOs, Step Robotics
8	Resistance from DISCOs	• Incentivize DISCOs through innovative business models involving DISCOs	DISCOs, NEPRA, AEDB

Issue	Recommendations	Key Stakeholders
9 Lack of awareness about net metering among power consumers and consumers' perception of technology and performance risk	• Conduct an awareness-raising campaign	AEDB
10 Complicated process	• Standardize SOPs across DISCOs • Process automation	DISCOs, AEDB, Step Robotics
11 Limited availability of rooftop space	• Develop business models around wheeling	Third party providers

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ABBREVIATIONS & ACRONYMS

AEDB	Alternative Energy Development Board
BNEF	Bloomberg New Energy Finance
BSW-Solar	German Solar Association
CEA	Central Electricity Authority
DG	Distributed generation
DISCOs	Distribution companies
DT	Distribution transformer
EEG	German Renewable Energy Sources Act
EPC	Engineering Procurement and Construction
EU	European Union
EV	Electric Vehicle
FERC	Federal Electricity Regulatory Commission
FIP	Feed-in-Premium
FIT	Feed-In-Tariff
GHG	Green House Gas
GHI	Global Horizontal Irradiation
GIZ	Gesellschaft fur Internationale Zusammenarbeit (German development agency)
GoP	Government of Pakistan
GW	Gigawatt
GWh	Gigawatt hour
IA	Interconnection agreement
IEEE	Institute of Electrical and Electronics Engineers
IESCO	Islamabad Electric Supply Company
IREC	Interstate Renewable Energy Council
kV	kilo Volt
kW	Kilowatt
kWh	Kilowatt hour
LBNL	Lawrence Berkley National Labs
LBNL	Lawrence Berkley National Labs
LCOE	Levelized Cost of Electricity
LCOE	Levelized Cost of Energy
LV	Low voltage
M&B	Metering and Billing
MV	Medium voltage
MW	Megawatt
NA	Net account
NEG	Net excess generation
NEPRA	National Electric Power Regulatory Authority
NGO	Non-governmental Organization
NM	Net metering
NP	Net-plus

NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
PEPCO	Pakistan Electric Power Company
PKR	Pakistan Rupee
PPA	Power Purchase Agreement
PPP	Power Purchase Price
PRI	Political Risk Insurance
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
REAP	Renewable Energy Association of Pakistan
RECs	Renewable Energy Certificates
RPS	Renewable Portfolio Standard
SEP	USAID Sustainable Energy for Pakistan
SHS	Solar Home Systems
SIA	Standard Interconnection Agreement
SOPs	Standard Operating Procedures
T&D	Transmission and distribution
ToD	Time of Day
ToU	Time of Use
USA	United State of America
USD	United State Dollar
VAT	Value Added Tax
VoS	Value-of-Solar
VRE	Variable Renewable Energy

1. INTRODUCTION

Pakistan introduced a net metering policy in 2006 (under the *Policy for Development of Renewable Energy for Power Generation, 2006*) and followed up with regulatory guidelines in 2015 (*National Electric Power Regulatory Authority Distributed Generation and Net Metering Regulations, 2015*) to promote power generation from distributed Renewable Energy (RE) installations. The growth in net metering installations is however slow, with only 815 net metering licenses issued by the electricity regulator through December 2018, adding 17.38 MW to the country's installed power generation capacity[1]. Considering Pakistan's RE potential - the country has some of the best RE resources in the world, especially solar insolation levels that exceed global averages in much of the country - the slow growth of the net metering market is a missed opportunity for Pakistan.

Given adequate policy support, distributed generation (DG) from solar PV (or rooftop solar) alone could add several Gigawatts of power to the national grid over the next few years, meeting a significant share of the national electricity demand. In addition to delivering generation capacity, DG has the potential to bring valuable grid-benefits to the power network in the country, especially where transmission and distribution losses are high or local transformers are loaded beyond capacity.

The objective of this report is to develop a strategic plan for growing the net metering market in Pakistan and identify specific interventions that are required to increase the uptake of net metering installations. The report therefore examines the current state of the net metering market in Pakistan, with a focus on the adequacy of the regulatory regime and barriers in the enabling environment that limit or curtail the effectiveness of the net metering program.

The overview of policies, regulatory regime and country experiences in Sections 2 and 3 is based on a literature review of the extensive research on DG and net metering. Information on the net metering market in Pakistan, including the cost of equipment, quality control and barriers to market growth, was sourced from AEDB and the Renewable Energy Association of Pakistan (REAP). To identify market barriers, SEP held a consultation on net metering in October 2018 with net metering installation companies associated with REAP and through interviews with select DISCOs and individual service providers in Karachi, Lahore and Islamabad. The analysis in the report is organized as follows:

Section 2: Overview of Distributed Generation and Net Metering

Describes the rationale behind policy support for RE in general and DG in particular and provides an overview of policy mechanisms adopted by countries around the world to promote power generation from RE technologies, including DG installations.

Section 3: Global Lessons on Implementing Net Metering

Describes a set of guiding principles for implementing net metering programs and global 'best-practice' for the design of net metering regulations. This section also identifies additional government incentives that are frequently offered in combination with net metering policies and the barriers curtailing net metering proliferation in emerging markets. A final part of the review discusses impacts of net metering on stakeholders, including distribution companies (DISCOs).

Section 4: Net Metering in Pakistan: Situation Analysis

the net metering eco-system in Pakistan to determine policy or regulatory gaps and identify barriers in the enabling environment that are inhibiting the growth of the net metering market. This section also reviews net metering support programs that are being implemented by the Alternative Energy Development Board (AEDB) and foreign development organizations in Pakistan.

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1 Dr. Irfan Yousaf, Director, Alternative Energy Development Board.

Section 5: Recommendations

Makes specific recommendations to address gaps in the regulatory structure and barriers in the enabling environment. An outline of a public awareness campaign to familiarize electricity consumers with the benefits of net metering and the process for subscribing to the program is also included.

2. OVERVIEW OF DISTRIBUTED GENERATION

Global growth in RE capacity reached record levels in 2017 with wind, solar, biomass, waste-to-energy, geothermal, small hydro and marine sources together adding 157 GW to the energy supply. The resulting shift in the global energy generation mix is reflected in RE's growing share in capacity, investment and electricity supply. In 2017, RE (excluding large hydro) accounted for 19% of the cumulative world generation capacity, 12.1% of electricity production and more than 58% of global investment in energy[2].

The increase in RE generation around the world is driven primarily by advances in RE technology (including falling equipment prices) and targeted public policies. By 2017, at least 128 countries (see **Figure 2.1**) had one or more national or state/provincial level policies, (including feed-in tariffs or premiums, tendering or auctions, net metering and Renewable Portfolio Standards or Renewable Obligations) in place to promote the production and use of renewable electric power[3].

In addition to grid-scale RE projects, many countries have adopted targeted policies such as Feed-in-Tariffs (FITs) and net metering to promote power production from distributed generation (DG) technologies. As a result, global installed residential and commercial PV capacity reached 173 GW in 2017, growing by 28 GW, a slight increase on the 22 GW added the previous year[4]. Countries including Germany, Japan and Australia currently produce more RE from small, distributed installations connected to the grid at the low voltage (LV) and medium voltage (MV) level than large, grid-scale power plants[5].

Figure 2.1: Number of Countries with Renewable Energy Policies, by Sector (2004-2017)[6]

2 FS-UNEP/BNEF, *Global Trends in Renewable Energy Investment 2018* (Frankfurt, Germany: Frankfurt School-UNEP Center, 2018).

3 REN21, *Renewables 2018: Global Status Report*, http://www.ren21.net/gsr-2018.

4 BNEF, "*New Energy Outlook*", 2018, https://about.bnef.com/new-energy-outlook/.

5 Dalia Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*", *Policy Research Working Paper* (Washington, D.C.: World Bank, June 2017).

6 REN21, *Renewables 2018: Global Status Report*, http://www.ren21.net/gsr-2018.

2.1.1 POLICY SUPPORT FOR RENEWABLE ENERGY

Policy support for RE is provided as a component of a country's broader energy sector policies, such as fossil fuel subsidies, cap-and-trade schemes or emissions taxes, designed to correct specific market failures or meet developmental goals. Many government programs supporting RE are designed to respond to the 'energy trilemma'; the need to provide energy that is environmentally sustainable, secure (or reliable) and affordable.

Globally, the most widely cited objectives for government support to RE programs include:

- **Transitioning to a cleaner, more sustainable power delivery system -** The external costs of fossil fuels and nuclear power are unsustainable over the long term. Many countries have adopted RE policies to affect structural change in their energy industries, enabling the transition to a 'greener', more sustainable energy delivery system[7].
- **Enhancing national energy security** - Substituting imported fuels with indigenous, renewable sources of energy reduces import dependence and exposure to fuel price volatility, providing energy security to countries with few or no indigenous fossil fuel resources[8].
- **Mitigating climate change -** Renewable energy, particularly solar energy, holds the potential to meet the world's growing energy needs while cutting greenhouse gas emissions[9]. Many national commitments to support renewable energy have been made through climate change policies with specific renewable energy and energy efficiency goals.
- **Reducing the cost of air-pollution and environmental degradation -** The impact of conventional power generation on air quality and biodiversity translates into significant financial costs, especially for developing nations that consistently rank low on international indices measuring air-quality and GHG reduction[10].
- **Providing access to energy** - Energy poverty (the lack of access to electricity and modern energy services) effects almost 3 billion people worldwide. Adopting renewable energy technologies such as distributed generation (DG), solar home systems (SHS), captive power projects and micro-grids, enable governments in developing countries to provide access to affordable, modern energy services, while circumventing the limitations of inadequate grid infrastructure and insufficient generation capacity.

Despite remarkable growth in RE investments over the last decade, RE accounted for only 1.8% of global **energy** consumption 2016[11]; global **electricity** production from RE was approximately 12% during the same period. The competitive position of RE relative to conventional energy sources was historically impacted by three main challenges:[12]

- Affordability and availability of the technology
- The levelized cost of energy (LCOE) for RE generation
- Integration of variable RE into the existing electric systems that are designed for centralized, dispatchable generation

In recent years however, rapidly falling prices for wind and solar technologies have enabled grid-scale wind and solar generators to achieve grid-parity, with LCOE for wind and solar falling below

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7 W. Rickerson et al., "*Residential Prosumers - Drivers and Policy Options*" (IEA-RETD, September 2014).

8 FS-UNEP/BNEF, "*Global Trends in Renewable Energy Investment 2018*."

9 MIT, "The Future of Solar Energy, MIT Study, MIT Future of Series (Cambridge, MA: Massachusetts Institute of Technology, 2015).

10 Jay Emerson et al., "*2010 Environmental Performance Index*" (New Haven: Yale Center for Environmental Law and Policy, 2010).

11 REN21, "*RENEWABLES 2018 GLOBAL STATUS REPORT*."

12 MIT, "*The Future of Solar Energy*."

conventional generators.[13] Countries around the world however continue to employ a mix of policy and financial instruments to promote the growth of RE and accelerate the transition to a greener, more sustainable energy system. The main categories* of public (policy and financial) incentives driving the growth of renewable energy globally are described in **Table 2.1**.

Table 2.1: Public Instruments to Promote Renewable Energy Deployment (Adapted from Multiple Sources[14])

	Direct	Indirect
Policy Instruments	**Price-based Instruments** *(Benefits proportional to the amount of electricity produced)* Feed-in-Tariffs (FITs), Feed-in-Premiums (FIPs or Premium Tariffs), corporate income tax credits	**Implicit payments or discounts** Net-metering or other DG compensation mechanisms implemented indirectly
	Quantity-based Instruments or Quota Obligations RE Targets, Tradable Green Certificates (Renewable Energy Certificates or RECs), Renewable Portfolio Standards (RPS), Competitive procurement mechanisms (tenders, auctions)	**Institutional support** Positive discriminatory rules e.g. regulations facilitating grid access (by simplifying permitting, installation and inspection and setting interconnection standards etc.) dispatch priority, building codes
Financial Instruments	**Investment-based Instruments** *(Upfront subsidies to reduce the cost of installing RE systems)* Financial instruments including grants, tax reduction, low-interest loans, reduction in property taxes etc. and public loan guarantees, public equity, partial risk guarantees on PPAs, counterparty guarantees as part of political risk insurance (PRI)	**Institutional Support** Policies to reduce the balance-of-system costs e.g. below-cost provision of infrastructure or services and R&D funding for RE technology

* Most literature sources classify public support mechanisms for renewable energy as 'policy and financial instruments' (Waissbein et al, 2013) or 'direct and indirect' policies (Azuela and Barroso, 2012, De Boeck et al. 2016, Batlle et al., 2011, Haas et al., 2011) with financial instruments included under 'direct' policies. Jenner et al. (2012) categorize support mechanisms into 'investment and generation' policies.

2.2 ADVANTAGES OF GRID CONNECTED DISTRIBUTED RENEWABLE ENERGY GENERATION

Distributed generation (also called on-site generation, dispersed generation, embedded generation, decentralized generation and distributed energy) generates electricity from small energy systems, at or near the point of consumption. Placed on roof-tops or ground-mounted, grid-connected distributed generators are located on the customer side of the meter and are used to offset the customer's energy

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[13] Lazard, "*Lazard's Levelized Cost of Energy Analysis - Version 12.0*", November 2018.

[14] Gabriela Elizondo Azuela and Luiz Augusto Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries*" (World Bank, 2012); C. Batlle, I.J Perez-Arriaga, and P. Zambrano-Barragan, "*Regulatory Design for RES-E Support Mechanisms: Learning Curves, Market Structure, and Burden-Sharing*" (MIT Center for Energy and Environmental Policy Research, May 2011).

consumption or provide grid support through peak shaving, load shifting and ancillary services. Distributed generation (DG), along with digitalization and decarbonization, make up key components of the global energy shift.

Distributed solar PV is currently the only DG technology with significant market penetration, however electric vehicles (EVs), combined heat and power generators, micro wind turbines and fuel cells all have the potential to make bigger contributions to DG in the future. The economic case for DG is primarily built on rapidly falling costs of solar PV technology and the fact that renewable energy generation from distributed solar PV has reached, or will shortly reach, grid parity in many countries[15]. Although grid-scale generation continues to have better economies of scale in most regions of the world, 63 countries had policies in place by 2017 to support distributed renewable energy generation[16].

In addition to the environmental benefits of DG from RE resources, government support for DG is motivated by the additional benefits that DG systems can potentially deliver to stakeholders including consumers, distribution companies (DISCOs) and transmission network owners (see **Annex I** for a detailed list of benefits associated with DG systems). The benefits attributed to DG include:

- **Mobilizing private finance** - DG installations at private residences and industrial or commercial locations are primarily financed through private funds. Policies to promote on-site DG are therefore considered effective for mobilizing private finance to fund the green-energy transition.[17]
- **Reducing transmission investment -** DG can reduce transmission investments, especially when combined with batteries or other forms of storage. This ability however relies on the location of DG, network topology, and power system technical constraints[18].
- **Providing grid support -** Coupled with storage and demand response technologies, DG has the potential to provide grid benefits such as frequency and voltage control[19].
- **Managing the role of 'prosumers' in the energy-transition -** Energy consumers in countries including Germany and Australia can profitably install and configure DG systems for self-consumption without exporting power to the grid. With reductions in the cost of solar PV and battery technologies, these so-called 'prosumers' could disrupt the existing energy delivery systems. DG policies enable governments to better manage the growth of prosumers[20].
- **Addressing land-use constraints -** Rooftop PV installations can help address land use constraints in island-nations and densely populated countries such as India[21].

2.3 GLOBAL INVESTMENTS IN DISTRIBUTED GENERATION

Driven mainly by government policy in the form of financial subsidies, global investment in solar projects of less than 1 MW (including off-grid units in remote areas) has grown significantly since 2004, reaching a peak-investment of more than $75 billion in 2011, bolstered by generous DG support schemes in EU countries (see **Figure 2.2** and **Figure 2.3**). In 2017, investment in small-scale projects

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15 Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*."

16 REN21, "*RENEWABLES 2018 GLOBAL STATUS REPORT*", 21.

17 Elizabeth Doris, Sarah Busche, and Stephen Hockett, "*Net Metering Policy Development in Minnesota: Overview of Trends in Nationwide Policy Development and Implications of Increasing the Eligible System Size Cap*", Technical Report (Golden, Colorado: NREL, US Department of Energy, December 2009).

18 Junhua Zhao and John Foster, "*Investigating the Impacts of Distributed Generation on Transmission Expansion Cost: An Australian Case Study*", *Energy Economics and Management Group Working Papers* 2 (2010).

19 Travis Lowder, Ella Zhou, and Tian Tian, "*Evolving Distributed Generation Support Mechanisms: Case Studies from United States, Germany, United Kingdom, and Australia*", Technical Report (National Renewable Energy Laboratory, 2017).

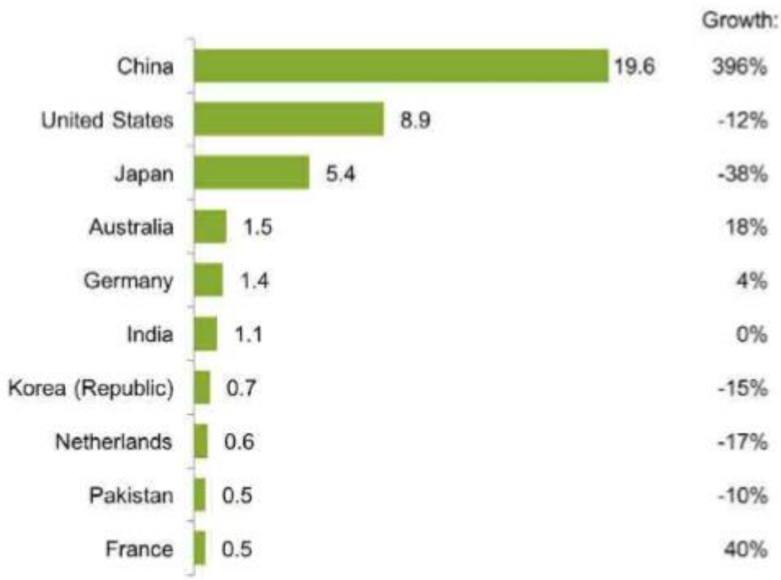
20 Rickerson et al., "*Residential Prosumers - Drivers and Policy Options*."

21 Amy Rose et al., "*Solar Power Applications in the Developing World*" (Massachusetts Institute of Technology, 2015).

increased by 15% to $49.4 billion, with China alone recording $19.6 billion, a fivefold increase on 2016. China accounted for almost 40% of the total global investment in small-scale solar projects in 2017[22]. Global installed residential and commercial PV capacity grew by 28GW to 173GW in 2017, recording an increase of 27% on the 22GW added in 2016. The cumulative capacity of residential and commercial PV has doubled since 2013 and grown more than five times since 2010.[23]

Japan leads the world in residential and commercial PV capacity, with 36GW installed by the end of 2017. With the exception of China, each of the top six countries listed in **Figure 2.2** has achieved 'commercial PV socket parity' (i.e. commercial rooftop solar electricity in these countries is cheaper than electricity from the grid), while Australia and Germany have also attained 'residential PV socket parity'. BNEF predicts China, the U.S. and almost all of Europe will be at socket parity by 2025.[24]

Figure 2.2: Top 10 Countries by Investment in Solar PV Projects Below 1MW, 2017, and Growth on 2016, $BN[25]



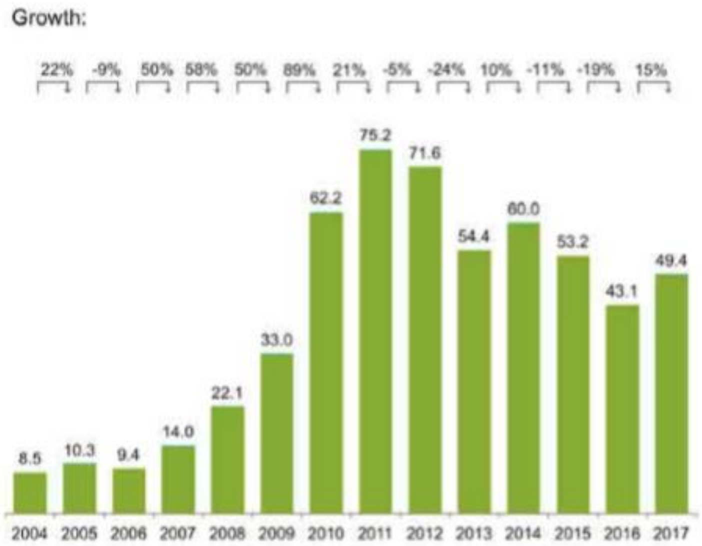
[22] BNEF, "*New Energy Outlook*."

[23] FS-UNEP/BNEF, "*Global Trends in Renewable Energy Investment 2018*." (Frankfurt, Germany: Frankfurt School-UNEP Center, 2018).

[24] FS-UNEP/BNEF

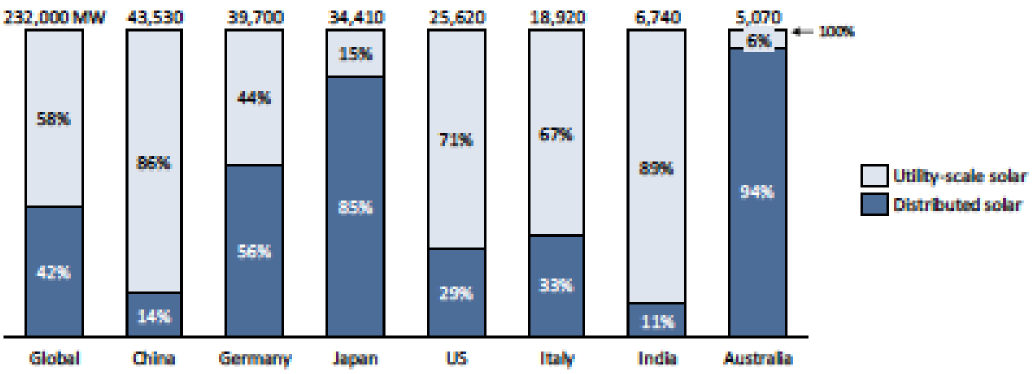
[25] FS-UNEP/BNEF

Figure 2.3: Investment Growth in Solar PV Projects with Capacities below 1 MW, 2004-2017, $BN[26]



Australia, Germany and Japan currently produce more solar energy from DG than centralized, grid-scale solar (see **Figure 2.4**). Australian rooftop solar installations reached a record in April 2018, with more than 100MW of solar installed each month, for seven consecutive months.[27] Coupled with small-scale batteries and grid-level demand response, DG is leading to increasingly decentralized energy systems in the leading markets for distributed solar PV. According to BNEF, Australia could achieve as much as 45% of total capacity located behind-the-meter by 2040 with Brazil, Japan, Mexico and Germany each projected to have a decentralization ratio of more than 30%[28].

Figure 2.4: Share of Utility-scale and Distributed Solar Globally and in the Seven Largest Markets, Ordered by Total Market Size [29]



[26] FS-UNEP/BNEF.

[27] Cole Latimer, "*New Rooftop Solar Adding Equivalent of Coal-Fired Power Station Every Year*", *Sydney Morning Herald*, May 2018, sec. Energy.

[28] BNEF, "*New Energy Outlook*."

[29] Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*."

PV comprises nearly a quarter of the installed generation capacity in Germany, and, on days of high production, PV can meet over a third of Germany's momentary peak demand[30]. The proportions for Germany in **Figure 2.4** represent DG connected to the low voltage (LV) grid only. However, a significant share of DG in Germany is connected to the medium voltage (MV) grid. In 2016, the country's cumulative installed PV capacity reached 40 GW, of which 98% is 'distributed' (i.e. interconnected at the low or medium voltage distribution level and serves loads close to the system) and 50% is owned by private citizens[31].

2.4 POLICY MECHANISMS FOR PROMOTING GRID-CONNECTED DISTRIBUTED GENERATION

Compensation mechanisms are the leading form of policy support for distributed generation projects worldwide. A compensation mechanism is a system of payments to residential, commercial and/or industrial consumers for on-site production of energy, designed to improve the value proposition of the DG investment for individual electricity consumers. Compensation mechanisms are one of several policy and regulatory options that can address challenges associated with deploying DG systems. Others include direct financial incentives (e.g., cash rebates, tax credits) and low-interest financing programs. In 2017, 63 countries had a compensation mechanism in place to support DG, through either a net-metering or net billing arrangement[32].

A compensation mechanism is composed of three core elements (see **Figure 2.5**):

2.4.1 METERING & BILLING ARRANGEMENTS

This element defines how consumption and generation related electricity flows are measured and billed. There are three generic options for metering & billing: Net metering, Buy All-Sell all (also known as gross-metering) and net billing. The selection of a metering & billing arrangement only establishes the measurement and billing of electricity flows to or from the grid and does not affect the rate of compensation provided to a DG system owner. Each metering and billing arrangement is associated with a different set of advantages and disadvantages (see **Annex 2**). In general, net metering or buy all-sell all (with an associated FIT) are the preferred mechanism for nascent markets where DG installations are negligible and compensation for DG owners is a relatively new policy. Policy makers typically transition to net billing once a market for DG is successfully established and growing at an acceptable pace.

2.4.2 RETAIL RATE DESIGN

The retail rate (known as the retail tariff in Pakistan) defines the retail tariff structure and precise electricity purchase rates the DG system owner must pay for electricity received from the grid. The retail rate design determines which costs the DG system owners can avoid if they consume self-generated electricity instead of buying electricity from the grid.

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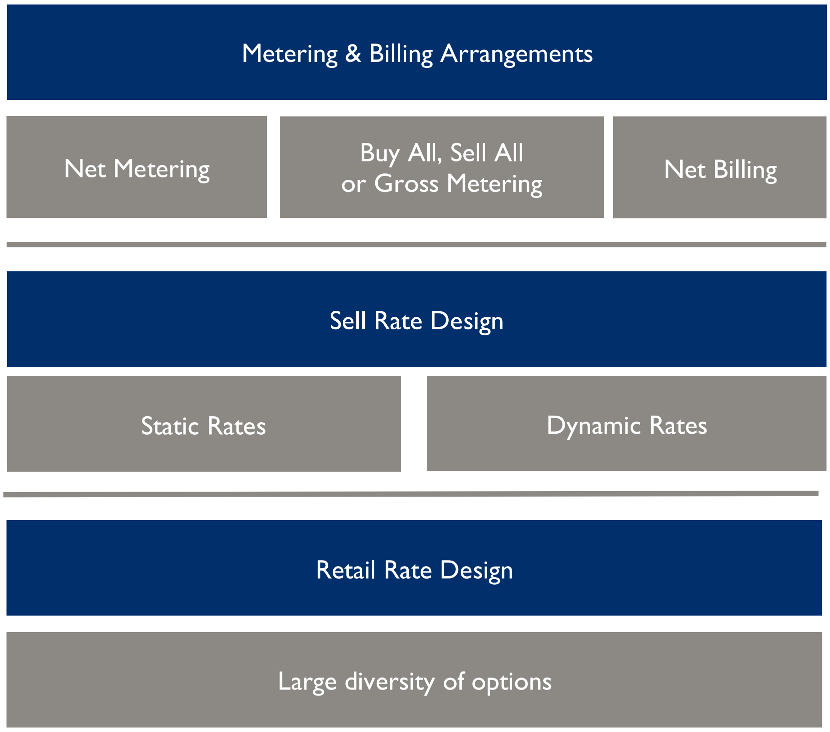
30 Heinrich Boll, "*Energy Transition - The Global Energiewende*", 2016; Harry Wirth, "*Recent Facts about Photovoltaics in Germany*" (Fraunhofer ISE, June 14, 2016).

31 Wirth, "*Recent Facts about Photovoltaics in Germany*"; M.R. Weimar et al., "*Integrating Renewable Generation into Grid Operations*" (Richland, WA: Pacific Northwest National Laboratory., 2016).

32 REN21, "*RENEWABLES 2018 GLOBAL STATUS REPORT*."

Figure 2.5: Components of a Compensation Mechanism (Adapted from Original Source[33])



2.4.3 SELL RATE DESIGN

This element defines the level of compensation a DG system owner receives for electricity exported from the DG system to the distribution grid. Depending on the metering and billing arrangement selected, the sell rate is applied to a set quantity of electricity that the DG system owner is authorized to sell or export to the grid quantities. Sell rates can be static, remaining fixed over the length of an interconnection contract or dynamic, changing with time (Time-of-Use rates) or by location, with various degrees of granularity[34]. Feed-in-Tariffs or FITs are an example of sell-rate design.

In countries with significant installed capacity of distributed solar PV, the markets for distributed PV grew rapidly as a result of government policies facilitating high rates of return on DG investment (Grau, 2014). The most common form of policy incentives for grid-connected DG are net metering (in the US, Brazil, India and Sri Lanka) and FITs (in Germany, Italy, Japan, Thailand and Australia)[35]. Original net metering and FITs have been instrumental in establishing thriving markets for distributed generation from solar PV. Prior to restructuring in 2012 and 2014 through the German Renewable Energy Sources Act (EEG), Germany's FIT was considered one of the strongest renewable energy support policies in the world. FIT rates in the country were significantly reduced for all classes of PV systems starting in 2012, resulting in an 80% decline in the annual PV installations by 2015[36].

* The terminology around compensation mechanisms varies across literature sources and is often misunderstood. Most literature sources describe net metering, gross metering, net-billing, FITs and PPAs as compensation mechanisms without addressing the distinctions in metering and billing arrangements or sell and buy rates. This report uses the framework and terminology defined by NREL in Zinaman et al., 2017 (see **Figure 2.5**).

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33 Owen Zinaman et al., "*Grid-Connected Distributed Generation: Compensation Mechanism Basics*" (National Renewable Energy Laboratory (NREL), October 2017).

34 Zinaman et al.

35 Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*"; CNEE, "*Net Metering and Net Metering Aggregation*" (Center For The New Energy Economy (CNEE), 2016).

36 Lowder, Zhou, and Tian, "*Evolving Distributed Generation Support Mechanisms: Case Studies from United States, Germany, United Kingdom, and Australia.*"

3. GLOBAL LESSONS ON IMPLEMENTING NET METERING

The concept of net metering originated in the United States in 1983, due to requests from grid-connected customers with micro-solar PV and wind facilities.17 The first formal pilot program was established in 1995 and begun implementation in 1996 in California. Denmark became the second country to adopt a pilot program in 1998[37]. Net metering has proven to be an effective enabling policy for the residential segment of the distributed generation market. Traditional net metering allows for a consumer's electricity meter to spin backwards, effectively erasing the cost of some of the electricity consumed from the grid in exchange for injecting electricity produced by the consumer, back into the grid. The mechanism relatively simple to implement for both DG system owners and DISCOs, can be easily incorporated with existing retail electricity tariffs and does not always require utilities to administer payments to electricity customers with net metering installations (see **Table 3.1** for bill settlement options available to DISCOs).

Net metering provides several benefits to various stakeholders;

- The policy promotes production of electricity, freeing up existing generation resources and delivering benefits similar to demand side management or energy efficiency to DISCOs.
- Coupled with modern inverters, net metering can provide support for grid stabilization.
- Electricity consumers with net metering installations can save on electricity bills by reducing power consumption from the grid (use self-generated electricity instead) and off-setting the cost of grid-supply by feeding electricity back into the grid.
- Policymakers can leverage significant private investment for RE generation through net metering policies since these installations are typically financed by individual consumers.

Although net metering can benefit all power system stakeholders, increasing levels of DG on grid-networks can also induce costs that impact stakeholders and society at large in different ways. For instance, DISCOs stand to lose revenue as consumption from the grid is replaced by self-generated power, without the DISCO receiving any compensation for the 'storage' and balancing service it must continue to provide to net metered customers. In addition, the benefits provided by DG to the DISCOs can be location specific and vary based on the period during which electricity is sold back to the grid, the demand profile of the producer and insolation levels at the point of generation, among other factors. Over-capacity and un-planned proliferation of DG and net metering can therefore impact grid stability and power supply quality (see **Annex 1** for a comprehensive review of the costs and benefits associated with generating renewable energy from DG installations).

Given these impacts, net metering schemes should ideally be developed in the context of the overall power system plan. Key considerations for incorporating DG or net metering in power system planning include the effects of the policy on consumers without net metering installations (cross-subsidization concerns), financial and technical impacts on DISCOs and positive externalities such as a reduction in environmental pollution.

This section of the report summarizes the net metering experiences of countries with developed DG markets. Based on country case-studies and academic research, a set of 'guiding principles for net metering program implementation' (**Section 3.1**) and 'global best-practice in regulatory design' (**Section 3.2**) are outlined first. Subsequent sections review the additional incentives required to successfully implement net metering programs and market barriers that typically curtail the growth of net metering in developing countries.

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[37] CNEE, "*Net Metering and Net Metering Aggregation.*"

3.1 GUIDING PRINCIPLES FOR NET METERING POLICY DESIGN AND MARKET ROLLOUT

Policies such as net metering and FITs are used as cornerstone instruments* in countries where grid-connected DG, especially distributed solar PV, has grown significantly. These policies and the regulations associated with them are however only effective and economically efficient when designed to cater to the local market environment and implemented through a carefully devised plan. Adequate planning for program implementation (rollout) also mitigates many of the technical and financial challenges associated with DG and net metering (see **Annex 2** for a detailed discussion on the technical and financial impacts of DG and net metering). Studies by international development organizations and academic research identify several principles that can improve policy and regulatory design and deliver better results from program implementation:

- Guiding principles for policy and regulatory design
    - Choice and complexity of the policy and regulations

    Policy and regulatory design is a largely context-specific process; a compensation policy that is successful in one part of the world can fail to achieve comparable results in other regions. The choice and complexity of policies and regulations should therefore be tailored to the context of the local market, including supply and demand volume, nature and level of risks and institutional and administrative capacity. (see **Table 3.1** for an overview of typical regulatory design elements and the standards applied to these in successful, global DG compensation programs). Individual regulatory elements should also be coordinated with wider conditions in the energy market and potential impacts on stakeholders[38].

    - Suitability of policies and regulations to sectoral maturity of the RE industry

    Support or incentives provided to RE should be appropriate for sectoral maturity of the RE industry in a country (Newbery et al, 2011) and the technologies receiving support[39]. For instance, in nascent DG markets, policy instruments such as FITs and Net metering (in combination with additional financial or fiscal incentives) can be very effective in establishing and growing the market for DG. Once the incentives achieve their objective, policies can be altered by reducing FIT payments, transitioning from net metering to net billing or withdrawing incentives entirely.

    - Presence of technical and institutional prerequisites

    Policy sequencing – having the basic legal, regulatory and technical prerequisites in place before adopting a new policy – is an important principle for developing a market for distributed generation. Institutional and administrative efficiency, frameworks for grid connection and integration, land rights and the allocation of permits are examples of prerequisites for a DG compensation policy to be effective[40].

* A cornerstone instrument targets key investment risks and is the foundation upon which all complementary policy and financial de-risking instruments are built.[41].

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38 Azuela and Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries.*"

39 Batlle, Perez-Arriaga, and Zambrano-Barragan, "*Regulatory Design for RES-E Support Mechanisms: Learning Curves, Market Structure, and Burden-Sharing.*"

40 Azuela and Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries.*"

41 Oliver Waissbein et al., "*Derisking Renewable Energy Investment- A Framework to Support Policymakers in Selecting Public Instruments to Promote Renewable Energy Investment in Developing Countries*" (UNDP, April 2013).

3.1.1 GUIDING PRINCIPLES FOR PROGRAM ROLLOUT

Well-designed net metering policies and regulations can fail to achieve their objectives if the policy or regulations are not accompanied by an appropriate implementation plan. In addition to providing guidelines for regulations, policymakers should therefore stipulate implementation rules at the outset of a net metering program, to improve the effectiveness of the policy and prevent or limit any unintended impacts. Key considerations for an effective policy implementation plan include:

- Treating policy and regulation as a dynamic process

  Net metering should only be a provisional policy intervention, enabling the transition of an energy system to a sustainable energy mix[42]. Policy adjustments or transition plans should therefore be embedded in the policy design and made publicly available. Making stakeholders aware in advance of planned or intended adjustments to the policy provides clarity to all stakeholders and enables DISCOs and investors to manage program related risks and costs.

- Starting with a restricted or pilot program

  Pilot or restricted programs are helpful in testing the design limits of policies without significant impact on any single stakeholder[43]. The limit or scope of a pilot net metering program can be defined by a number of threshold criteria including the maximum allowable participants in the program, the total installed capacity of the net metering installations in MW or by defining the type of consumer eligible to participate in the program (for instance, limiting participation to electricity consumers with 3-phase power supply connections).

- Assessing technical and financial impacts on DISCOs

  An upfront review of the technical impacts of net metering on low-voltage distribution networks allows for systematic development of policy frameworks, reducing risks to distribution companies and investors, and providing stability over the investment time frame. Technical impacts that need to be analyzed and quantified include the impact of DG on network harmonics (including voltage and frequency regulation) and the potential for reverse power flow from the low-voltage to the medium-voltage network. A financial impact assessment is useful in limiting the impact on DISCO revenues and consumers without net metering installations.

- Reviewing effects on energy network performance

  The impact of net metering regulations on the energy network performance in the short-run (operations) and in the long-run (expansion) should be considered and optimized across both time horizons. When planned and implemented correctly, net metering programs can relieve nodal congestion on electricity networks in the short-term and reduce the cost of network expansion in the long-term.

- Transitioning to alternatives to net metering

  The penetration level of DG should be the leading criteria for altering or terminating net metering programs. Penetration levels can be defined in terms of the cumulative capacity of net metered installations, as a percentage of a network's generation capacity or a percentage of peak-demand on a network. Once a network achieves a predefined level of net metered installations, compensation for DG can be adjusted (by offering an alternative compensation scheme) or phased-out entirely. Common alternatives to net metering programs include net billing or value-of-solar (VoS) tariffs and the application of fixed and variables charges to net metered customers, among other options.

42 Azuela and Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries.*"

43 CNEE, "*Net Metering and Net Metering Aggregation*."

3.2 BEST PRACTICE IN NET METERING REGULATION DESIGN AND INTERCONNECTION STANDARDS

3.2.1 REGULATORY DESIGN

Net metering regulations define the scope and impact of a net metering program. Generally, the differences between net metering regulations across countries stem from local market conditions, the structure of the power sector and the policy objective behind the scheme. Other important considerations for setting regulatory design parameters include the availability of supporting financial incentives and the expected impacts of the program on DISCOs and consumers without net metering installations (cross-subsidization impact). Net metering programs in most jurisdictions define and set limits on:

- Metering and billing arrangements
- Sell-rate design
- Contract length
- Program size cap
- System size cap
- Local level cap
- Netting frequency (or credit reconciliation period)
- Crediting terms and
- Allowable net excess generation (NEG)

Additional elements that are also included in regulatory design, although less frequently, include technology eligibility, customer eligibility, ownership of renewable energy credits (where available), identifying DISCOs to participate in the scheme, assigning or disallowing additional fees and specifying business models that can be implemented based on net metering. **Table 3.1** describes the various regulatory elements and global best-practice in designing net metering regulations.

3.2.2 INTERCONNECTION STANDARDS

Interconnection standards set out the legal, technical and procedural requirements that electricity consumers, system installers and DISCOs must follow when connecting a distributed generator to the grid. While net metering and interconnection standards are different regulatory components, both are essential to increase the deployment of DG installations and should be designed to supplement each other. The interconnection of distributed generation is an important regulatory issue because of the safety and reliability issues associated with DG connecting to the electricity grid, however unnecessarily lengthy or complex interconnection rules can lead to delays and increase the cost of DG installations. By setting out a clear and efficient process for grid connection, interconnection standards mitigate some of the risks associated with DG grid connection while encouraging the development of the DG market.[44].

Historically, a lack of interconnection standards has been a major barrier to the development of the DG market in the United States and several entities at the federal and state levels have developed interconnection rules to streamline DG grid connection. In 2005, the Interstate Renewable Energy Council (IREC) compiled best-practices from state and federal actions on small generator interconnection to develop IREC's first ever interconnection procedures. Comprising model interconnection rules, model interconnection agreements and application forms, and technical

[44] Clean Coalition, "*Streamlining the Interconnection of Advanced Energy Solutions to the Grid*" (California Energy Commission, September 2017).

interconnection procedures, IREC promotes its interconnection rules as the best model for expedited, low-cost DG interconnection[45]. The IREC model is based on the IEEE 1547 quality and UL 1741 testing standards standard which allows distribution companies in the US to expedite the review of several protective functions of DG systems; for generators that comply with IEEE 1547, the Federal Electricity Regulatory Commission, FERC, allows the expedited interconnection of systems up to 10 kW. The interconnection procedures contained in the IREC model are divided into four areas[46]:

- Level 1: 10 kilowatts (kW) and smaller for certified inverters (residential-sized systems)
- Level 2: 2 MW and smaller, certified (commercial net metering and other systems)
- Level 3: 10 MW and smaller, certified, non-exporting (designed for combined-heat-and-power facilities)
- Level 4: All others up to 10 MW, including generators that do not qualify for other standards

The first three levels in the IREC model require a preliminary review by an independent third-party testing laboratory. The fourth category includes all DG installations that do not meet the criteria of the first three categories or require a complete review of their custom protection equipment. The goal of the IREC rules is to categorize all possible DG interconnections from least complex to most complex so that the fees and process for an interconnection application can be minimized while maintaining the highest level of safety and reliability [47]. Several countries have used the IREC model to develop their own interconnection rules.

[45] Chris Cook and Rusty Haynes, "*Analysis of US Interconnection and Net-Metering Policy*" (North Carolina Solar Center, n.d.).

[46] IREC, "*Model Interconnection Procedures*" (Interstate Renewable Energy Council (IREC), 2013).

[47] Chris Cook and Rusty Haynes, "Analysis of US Interconnection and Net-Metering Policy" (North Carolina Solar Center, n.d.).

Table 3.1: Net Metering Regulations: Design Elements and Best practice[48]

Design Element	Regulatory Options	Regulatory Best Practice
Metering & Billing Arrangement	• Net-metering • Net-billing (Inflow-Outflow) • Buy All- Sell All (BASA or Gross-metering)	**Net metering for nascent markets;** Net Metering (NM) is a relatively simple mechanism for both DG system owners and utilities to implement. Requires minimal oversight and limited public investment after implementation. **Net billing or gross-metering for mature markets:** Net billing or Buy all- sell all (BASA or gross metering) allows a more precise compensation for electricity injected into the grid relative to NM since the sell rate for exported electricity can be set to match the value to the utility. Cross-subsidization and utility impacts are relatively lower.
Sell Rate Design	• FiT (typically above retail rate) • Retail rate • Time-of-Use (ToU) • Avoided cost • Wholesale electricity rate (below retail) • Value of Solar (VoS) • No compensation	**Retail rates for compensation for electricity production during the credit reconciliation period**: In nascent markets, net-metering at retail rates (i.e. the meter spins backwards when the DG system feeds electricity into the grid) is the most effective sell-rate option. Cross-subsidization and impacts of utilities are an issue at higher levels of DG penetration. **Varies for compensation for 'net-excess' electricity production, at the end of the credit reconciliation period**: Net-excess electricity production at the end of a credit reconciliation period is either not compensated or compensated at a rate less than the retail price of electricity, as determined by regulators.

48 Doris, Busche, and Hockett, "*Net Metering Policy Development in Minnesota: Overview of Trends in Nationwide Policy Development and Implications of Increasing the Eligible System Size Cap*"; Julie Baldwin et al., "*Report on the MPSC Staff Study to Develop a Cost of Service-Based Distributed Generation Program Tariff*" (Michigan: MICHIGAN PUBLIC SERVICE COMMISSION, February 2018); Zinaman et al., "*Grid-Connected Distributed Generation: Compensation Mechanism Basics"; Patrick Curran and Gerrit W. Clarke, "Review of Net Metering Practices*" (Namibia: Electricity Control Board of Namibia, December 2012); PUC Sri Lanka, "*Net Metering Development in Sri Lanka*" (Public Utilities Commission of Sri Lanka, March 2016); IFC and Deloitte, "*Evolving Model Guidelines on Energy Accounting, Commercial/Tariff Arrangement for Proliferation of Rooftop Solar PV Projects*" (August 2013); Gridworks, "*Sustaining Solar Beyond Net Metering*" (Gridworks, January 2018); MIT, "*The Future of Solar Energy*"; CCSE, "*Best Practices for Interconnection Standards*" (California Center for Sustainable Energy, February 2013); IREC, "*Model Interconnection Procedures*"; B. Kroposki et al., "*Renewable Systems Interconnection*", Technical Report (Golden, Colorado: National Renewable Energy Lab. (NREL), Golden, CO (United States), February 2008).

Design Elements	Regulatory Options	Regulatory Best-Practise
Contract Length	• A specified number of years (e.g. 7 in Pakistan) • Life of the DG system	The contract length has an impact on the financial viability and risk profile of the DG system. In general, longer contract periods are preferable.
Program size cap	• Percentage of peak demand (e.g. 5% of Peak Demand) • Capacity limit (e.g. 500 MW) • Unlimited	**High program caps:** Utility revenue loss, distribution system configuration, diversity of consumers at feeder DTR level, over-all variability of generation, grid-stability and cost of up-gradation are the major design considerations for this category. In the US, the overall net metering cap for states varies from 0.1 – 20% of peak demand of local electricity utilities. Higher program caps are known to accelerate market growth.
System Size Cap	• Limit on installed capacity per unit (e.g. 10 kW) • Limit associated to the average, annual electricity demand in a region/country (e.g. average electricity demand of 300 kWh/a; 1% of 300 kWh=max size of 3kW • No direct caps (indirectly via roll-over provisions)	**A system size cap based on the customer's load profile:** Design considerations include policy objectives and technical constraints associated with the local distribution transformer capacity (power quality parameters move out of acceptable ranges). Almost half of US states with net metering policies have a system size cap of 2 MW. At low levels of DG penetration, IREC and NNEC recommend no limit on individual system size and propose the service entrance capacity and customer load/demand profiles as the only parameters to determine individual system size. Limits on the size of eligible systems can prevent customers from properly sizing their system to meet their electricity demand and inhibit the participation of some of the most cost effective systems. A higher system size cap leads to accelerated market transformation and a greater installed capacity without significant negative rate payer impacts.

Design Elements	Regulatory Options	Regulatory Best Practise
Local Level Cap	• Percentage of Distribution Transformer capacity	**15% of DT capacity initially**: Design considerations include distribution system configuration and diversity of consumers at feeder DTR level. Limit on grid-penetration at 15% of Distribution Transformer capacity is recommended in the first phase of net-metering programs especially where grid-infrastructure is weak or inadequate and upgrades might be required to accommodate high levels of DG penetration.
Netting Frequency and Credit Reconciliation Period *(Roll over period)* for Net Excess Generation (NEG)	• Yearly • Monthly • Daily • Hourly • Continuous roll-over	**Indefinite roll-over of NEG;** The main design considerations include the commercial interest of the utility and the available metering technology (e.g. smart or ToU meters). Electricity imports & exports are netted monthly in most US states, and reconciled annually. Longer reconciliation periods balance production against consumption and improve customer economics. More granular netting (e.g. daily or hourly) generally reduces solar customer economics, but may be considered when penetration levels increase, or in conjunction with deployment of other DG resources as storage.
Crediting Terms (Compensation for net-excess generation)	• Cyclic net-metering with Cash compensation (Commercial settlement) • Cyclic net-metering with no compensation • Cyclic net-metering with credit roll-over (Energy settlement) • Perpetual Credit roll-over (Energy settlement)	Driven by commercial interests and administrative capacity of the utility, cyclic net-metering and Perpetual roll-over are the two most common approaches for reconciling and crediting net excess generation. Cyclic net metering requires reconciliation of net-production after a pre-determined period (usually monthly or annually). At the end of the reconciliation period, the DG customer is compensated for excess kWh fed into the grid, at a rate lower than the retail price of electricity, with compensation provided as bill credits (energy settlement) or cash pay-outs (commercial settlement).

Design Elements	Regulatory Options	Regulatory Best Practise
		Some US states do not provide compensation for net excess generation and it is wiped out at the end of every reconciliation cycle. Cyclic reconciliation and compensation places increased administrative burden and cost on utilities and prevents customers from right-sizing their facilities. Perpetual rollover encourages customers to right-size DG installations, removes the complication of year-end accounting and physical pay-outs for utilities and allows for differences in the seasonal effects of renewable energy technologies.
Limit on Net Excess Generation (NEG) *Upper cap on the maximum amount of electricity that can be sold back to the utility*	Percentage of annual consumption	Impact on utility revenues is the guiding principle. Compensation for 'net-excess' energy injected into the grid can be limited to a percentage of energy consumption from the grid. e.g. commercial settlement provided for only 90% of total energy consumption in a financial year regardless of the total net-excess generation. Some jurisdictions such as the US state of Colorado allow compensation for up to 120% of a customer's average annual consumption.
Interconnection Standards, Codes and Guidelines	• Zero or reduced interconnection costs • Simplified interconnection contracts • Interconnection deadlines for utilities • Rapid review and interconnection for smaller systems (e.g. less than 10 kW) • Grid codes, equipment standards etc.	Driven by grid safety and stability concerns. Interconnection standards provide legal, technical and procedural requirements DG customers, installers and utilities must follow when connecting a DG system to the grid. Effective Interconnection standards increase DG uptake significantly and play a crucial role in removing market barriers to the development and deployment of DG systems. Ineffective or lacking standards can both increase the costs of DG installations and cause delays due to over-complex connection and administration procedures.

Design Elements	Regulatory Options	Regulatory Best Practice
		Many of the model interconnection procedures that PUCs review in establishing their own regulations come from four templates: The Federal Energy Regulatory Commission's Small Generator Interconnection Procedures (FERC 2015); the Mid-Atlantic Distributed Resources Initiative (MADRI 2015); California's Rule 21 (CPUC 2015); and the Interstate Renewable Energy Council's model interconnection standards (IREC 2013). Interconnection standards are critical to the growth of the DGPV market. Without a set of rules that explicitly facilitates the process, DGPV generators may not be able to come online once installation is finished, creating a lag that can strand investments, impact project economics and generally jeopardize market growth.
Technology Eligibility	Geothermal, Solar Thermal, Solar Photovoltaics, Wind, Biomass, Municipal Solid Waste, Fuel Cells, Landfill Gas, Tidal, Wave, Ocean Thermal, Hydroelectric (Small), Anaerobic Digestion	**All RE technologies are eligible:** Solar PV has emerged as the most popular technology for net metering due to resource abundance and reliability, ease of installation and declining costs. Inclusion of all RE resources provides a level-playing field to renewable energy technologies.
Customer Eligibility *(Applicable market segments)*	• Residential • Commercial & Institutional (government, nonprofit, schools, agricultural) • Industrial	**All classes of customers are eligible:** Retail electricity prices and socket-parity for the different market segments is the main design consideration. Some market segments (e.g. residential DG in India, where this segment is not at socket-parity) benefit more from DG compensation than others. Disallowing larger system sizes, by excluding the industrial segment for instance, curtails DG uptake. Allowing larger systems (non-residential customers) to net-meter can can lower the cost per kW of capacity across the country.

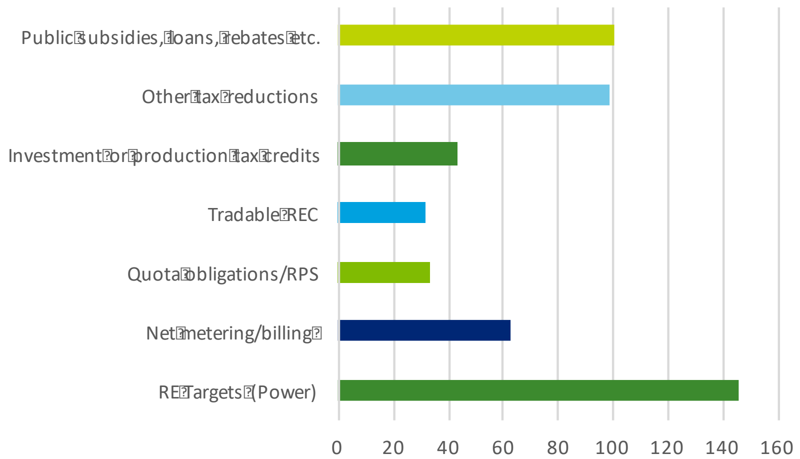
Design Elements	Regulatory Options	Regulatory Best Practise
Ownership of Renewable Energy Credits (REC)	Supporting policy measure; obligated entities (potential REC users) can include utilities and large industrial captive consumers.	**RECs owned by the customer generator:** RECs provide another stream of revenue for the owners of the DG system that produces RE. A majority of US states with net metering have determined that distributed generation customers own RECs. Some states such as Colorado provide up front support for DG installation. This rebate is provided in exchange for a customer's RECs, which are then used by utilities to meet regulatory requirements.
Identifying utilities that must offer the service	• Private utilities • Public utilities • Both public and private utilities	**Applies to all utilities:** Policies should be uniform across private and public utilities and all regions in a country or jurisdiction. Limiting policy implementation to specific regions and or utilities can impact the effectiveness of the policy.
Additional policy support *(Supporting incentives)*	• Capital subsidy • Tax rebates • Duty exemptions • RECs • Renewable Obligations • Exemption of banking and wheeling charges	**Additional support and incentives are required:** Most countries have used a combination of policy instruments, often combining performance based incentives (i.e., benefits proportional to the amount of electricity produced such as net-metering and FiTs) with upfront subsidies to reduce the cost of installing the solar system (e.g., rebates, grants, or low-interest loans).
Assigning or disallowing additional fees	• Connection charge • Net-metering charge • Fixed charges • Demand charges • Minimum bill	**DG customers should not be charged any additional fees:** Motivated by costs incurred by participating utilities as a direct result of DG uptake and the impact of cross-subsidization on utility customers without DG. Several US states have instituted additional fees.
Business Models *Ownership of assets and contracting mechanism*	• Self-owned (Capex or lease) • Third-party owned (PPA, roof-top lease) • Utility Owned (e.g. on-bill financing) • Meter aggregation • Virtual net metering	The third-party ownership model, which is currently allowed in half the US states has provided a significant boost to DG uptake in these jurisdictions, particularly in the residential segment of the market. DG uptake can expand more rapidly in the residential market if third party ownership is allowed.

3.3 ADDITIONAL INCENTIVES REQUIRED FOR SUCCESSFUL NET METERING PROGRAMS

Distributed generation compensation schemes, such as net metering, face inherent challenges and can rarely support the growth of DG without additional policy and financial incentives. In many countries, the market, for distributed solar PV for instance developed rapidly only after the government provided high rates of return on distributed solar investments through additional financial or fiscal incentives[49]. A 10-state case study in the US found that customer-owned distributed wind generation systems are not promoted through net metering policies alone, and additional incentives and educational programs are required to improve the uptake of DG[50].

As a result, net metering is often a single component of a suite of policy options to incentivize DISCO customers to install DG systems. Most countries use a combination of policy instruments (performance-based incentives where benefits are proportional to the amount of electricity produced e.g. FITs and net metering) and upfront subsidies that reduce the cost of installing the DG system (e.g. rebates, grants, or low-interest loans)[51]. Some countries provide additional incentives to specific market segments only. In Taiwan, for instance, a FIT based compensation scheme is employed to encouraging investment in systems under 10 kW[52]. The effectiveness of DG compensation schemes is strongly linked to the availability of fiscal and financial incentives in developing countries specifically, where RE investment risks are higher and more diverse[53].

Figure 3.1: Policy Incentives Provided to Renewable Energy in Countries around the World in 2018 *(Adapted from REN21, 2018)*



During the last decade, the most widely used incentives for increasing private investment in distributed solar PV installations include fiscal incentives and public financing thorough capital subsidies, VAT

49 T. Grau, "*Responsive Feed-in Tariff Adjustment to Dynamic Technology Development*" (Energy Economics, 2014), http://doi.org/10.1016/j.eneco.2014.03.015.

50 T.L. Forsyth, M. Pedan, and T. Gagliano, "*The Effects of Net Metering on the Use of Small-Scale Wind Systems in the United States*" (Golden, Colorado: National Renewable Energy Laboratory (NREL), 2002); Sanya Carley and Tyler R. Browne, "*Innovative US Energy Policy: A Review of States' Policy Experiences*", *WIREs Energy and Environment*, February 2012, https://doi.org/10.1002/wene.58.

51 Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*."

52 T. D. Couture et al., "*Next Generation of Renewable Electricity Policy: How Rapid Change Is Breaking Down Conventional Policy Categories*" (National Renewable Energy Lab. (NREL), Golden, CO (United States), February 1, 2015), https://doi.org/10.2172/1172282.

53 Azuela and Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries*."

reduction, taxes credits and public investment, loans, or grants etc.[54]. **Figure 3.1** shows the various policy incentives, in addition to FITs and net metering, that are offered in countries around the world to support renewable energy[55].

3.4 BARRIERS TO NET METERING MARKET GROWTH IN DEVELOPING COUNTRIES

Net metering policies can fail to deliver results if other critical aspects of the enabling environment for DG are not considered in parallel. Challenges related to the enabling environment or market conditions in emerging markets include system financing barriers (such as limited access to debt, lack of diversity in business models and financing risks associated with consumers and off-takers) and non-financial barriers (including institutional capacity issues and technical constraints such as the unavailability of adequate transmission infrastructure). Compensation policies such as net metering do not account for these barriers or mitigate the risks associated with them. Additional measures - capacity building of key institutions, provision of concessional finance and reduction of "soft-costs' through market pull strategies among others - are often required to remove the barriers limiting net metering uptake and reduce the investment risk associated with DG projects in developing countries[56].

The slow growth of grid-connected DG in both China and India highlights the relevance of this issue in emerging markets. Both countries have been unable to develop the DG market as intended, despite providing targeted policy support (net metering in India and FITs in China) and financial subsidies to the sector[57]. India has set ambitious targets for distributed solar PV, aiming to achieve 40 GW by 2022 however, the rooftop solar capacity in India was only 0.7 GW at the end of March 2016[58] and the country has recently scaled down its original target of 40 GW of rooftop solar power. The main challenges facing the growth of DG in India are well documented and include technology and market maturity, commercial viability, grid interconnection issues, resistance from incumbents (such as DISCOs and power sector operators), availability of financing and a general lack of public awareness about the utility and benefits of net metering [59].

China set a target to install 20 GW of DG capacity by 2015 and 35 GW by 2017. But similar to the DG experience in India, total DG installations stood at only 7.03 GW by the first quarter of 2016. Financing and interconnection issues are identified as the main barriers impacting the growth of distributed solar PV in China. The financing challenges stem from several issues, some inherent to the DG technology[60]:

- There is an inherent mismatch between the standard financing instruments on offer from the financial sector and the requirements of DG installations; The size of a typical net metered, DG installation is too small to attract capital market or fund investment and too big to be easily self-funded.

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54 L. Dusonchet and E. Telaretti, "*Comparative Economic Analysis of Support Policies for Solar PV in the Most Representative EU Countries*", *Renewable and Sustainable Energy Reviews*, no. 42 (2015): 986-98.

55 REN21, "*RENEWABLES 2018 GLOBAL STATUS REPORT*."

56 Azuela and Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries*."

57 ADB, "*Lesson Learnt from ADB India Solar Power Generation Guarantee Facility*", Volume II: Assessment of Alternate Financing Products, II (Asian Development Bank, 2015); X. Liang, "*Lost in Transmission - Distributed Solar Generation in China*" (China Environment Forum., 2014).

58 Sandeep Gupta, Jai Sharda, and Gireesh Shrimali, "*The Drivers and Challenges of Third Party Financing for Rooftop Solar Power in India*" (India: Climate Policy Initiative, September 2016).

59 Sarah Martin and Joshua N. Ryor, "*Prosumers in Bengaluru: Lessons for Sclaing Rooftop Solar PV*", Working Paper (Washington, D.C.: World Resources Institute, 2016).

60 Travis Lowder et al., "*Historical and Current U.S. Strategies for Boosting Distributed Generation*" (Colorado, USA, August 2015).

- Rooftop and land ownership issues makes DG more challenging; Residential projects are typically installed on apartment buildings and require the consensus of all building occupants. For commercial projects, the turnover of business ownership is more frequent than the life of the solar project itself. As a result, there are difficulties in using the solar project as collateral to obtain a bank loan[61].
- Low electricity tariffs discourage DG uptake; Despite the relatively high FIT rate offered in China, the DG photovoltaic (PV) market in the residential sector has not taken off. This is primarily due to low electricity prices for residential consumers, which in effect reduce the savings from using self-generated electricity and diminish the economic value of the DG installation.
- The high cost of financing DG systems is unaffordable for most electricity consumers; The financing cost for solar is generally above 8% and can be as high as 10% to12%. This is primarily due to the risks associated with the quality of the solar panels and the ability of the power consumer to repay the loan[62].

Many barriers to net metering, linked to the enabling environment or market are common across developing market countries. **Figure 3.2** provides an overview of the barriers that typically curtail the diffusion of DG and net metering technologies in developing countries:

Figure 3.2: Common Barriers to Net Metering Proliferation in Developing Countries

Financial Barriers	Technical Barriers
• High System cost: The cost of solar panels and other system hardware as well as the 'soft costs' associated with customer acquisition, labor rates, permitting etc. • Market distortions due to subsidized electricity rates • Lack of additional financial incentives (e.g. tax rebates, quotas, subsidized loans and grants etc.) or low and ineffective capital subsidies • Insufficient contract duration (impact debt acquisition) • Limited access to debt and high cost of financing due to risk associated with DGPV installations (quality of equipment, consumer credit risk, counterparty risk etc.)	• Technical impacts on the power-grid: Grid reliability issues and capacity limitations • Limited technical capacity of the program administrator • Grid interconnection challenges • Technology Maturity: Inverters have historically been the leading cause of PV systems failures. • Lack of access to data and knowledge. Uncertainly in projects developer selection (perceived performance risk.)

[61] Lijia Wang, "*Financing Difficulties for Distributed Solar PV*", *Energy (Chinese)* 2 (2014): 65–67.

[62] L. Dai, "*China's Solar PV Station and Distributed PV Both Facing Financing Problems*", *Energy Conservation and Environmental Protection*, 2014.

Institutional Barriers	Other Barriers
• Resistance from power sector incumbents such as utilities and power sector operators • Limited institutional capacity of the distribution companies to administrator the program • Complicated process for subscribing and lack of standardization across utilities • Market maturity	• Limited reach and appeal of the net-metering program, lack of public awareness about the availability of the program • Inadequate understanding of regulations, PV performance, cost, and payback amongst electricity consumers • Limited availability of suitable roof space • Land-ownership issues.

(Adapted from multiple sources[63])

3.5 IMPACTS ON STAKEHOLDERS

Increasing levels of DG on grid-networks produces costs and benefits that impacts energy system stakeholders and society at large in different ways (See **Annex I** for an overview of costs and benefits associated with distributed renewable energy generation). Important impacts of DG on power sector stakeholders include:

3.5.1 PROSUMERS

Prosumers (electricity consumers with DG or net metering installations) benefit from DG through cost savings on utility bills. There is broad support globally for the ability of consumers to install and operate DG systems on their own property and 'prosumers' are a growing consumer category in many countries.

3.5.2 GOVERNMENTS

Government decisions that constrain or enable prosumers can have significant financial implications on stakeholders and technical impacts on the electricity grid. Governments could also face a revenue loss from reduced tax collections.

3.5.3 INCUMBENT GENERATORS

Prosumers compete with incumbent generators and can impact their dispatch order and the revenues they generate from electricity supply. However, the emergence of prosumers could also provide new business opportunities to generation companies.

3.5.4 SUPPLY CHAIN (TECHNOLOGY PROVIDERS)

The growth of DG markets can significantly benefit technology providers in the DG industry with a positive impact on both services and manufacturing for distributed generation.

3.5.5 CONSUMERS

Net metering shifts a portion of the DG customer's allocated share of fixed and variable costs to customers without DG, creating a cross-subsidy effect. However, a recent study by Lawrence Berkley National Labs (LBNL) found that cost-shifting occurs when DG penetration exceeds 10% of grid-

63 PUC Sri Lanka, "*Net Metering Development in Sri Lanka*"; Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*"; JSF, "*Renewable Energy in Jordan*", (October 2017); Lowder, Zhou, and Tian, "*Evolving Distributed Generation Support Mechanisms: Case Studies from United States, Germany, United Kingdom, and Australia*"; BNEF, "*Accelerating India's Clean Energy Transition: The Future of Rooftop PV and Other Distributed Energy Markets in India*" (Bloomberg New Energy Finance, November 2017); Kroposki et al., "*Renewable Systems Interconnection*"; Martin and Ryor, "*Prosumers in Bengaluru: Lessons for Sclaing Rooftop Solar PV*."

supply. Currently only three states in the US are close to that level of DG penetration and even at 10%, the rate impact is only an increase of $0.005/kWh[64].

3.5.6 TRANSMISSION AND DISTRIBUTION COMPANIES

As consumption form the grid is replaced by distributed generation, transmission and distribution companies face impacts on revenues, network costs and grid stability:

- Impact on utility revenue

With growing penetration of DG, utilities stand to lose revenue (to the extent that recovery of distribution costs or charges is decreases) while incurring the same or increased costs for maintaining transmission and distribution capacity. Network companies also have to bear the cost of the difference in energy costs between the hours of generation and hours of consumption under net metering. However, the decrease in revenue can be compensated by revenue de-coupling mechanisms. Utilities can also benefit from DG if systems are appropriately situated within the grid, reducing congestion, curtailing transmission losses or decreasing transmission costs. Distribution companies are also potentially affected by administrative costs, but these can be offset at least partially by fees charged to DG customers.

- Impact on network costs

Distribution network energy losses and associated costs generally decline as the share of PV energy in a distribution network increases up to nearly 25%. At very high levels of PV penetration (beyond 25%), losses start to increase, and new investments are required to maintain quality of service. In areas of low insolation, without specific mitigating measures, distribution costs could double whenever annual DG contribution exceeds one-third of annual load[65]. Higher penetrations of DG can also lead to stress on conventional units from increased cycling. Although additional operations and maintenance costs due to increased cycling were found to be small compared to overall system production cost savings in one recent study[66].

- Impact on grid stability

The increased use of intermittent DG sources can affect grid stability. DG compensation programs such as net metering should therefore be incorporated in overall power system planning. Both technical and regulatory capacity is needed to ensure that net metering systems are installed correctly, that distribution networks are able to accommodate net metered systems and that the appropriate regulation is developed and implemented. Increased PV penetrations can cause voltage issues that could exceed the tolerance levels of installed equipment and cause frequency variations. Interconnection rules have traditionally been designed to assume that these impacts would be negligible below 15% of peak load on a distribution circuit, although in some cases higher levels have been achieved with no impacts on the circuit[67].

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64 Galen Barbose, "*Putting the Potential Rate Impacts of Distributed Solar into Context*", LBNL-1007060 (California, USA: Lawrence Berkley National Laboratory (Berkeley Lab), 2017).

65 MIT, "*The Future of Solar Energy*."

66 D. Lew et al., "*The Western Wind and Solar Integration Study Phase 2*" (National Renewable Energy Laboratory (NREL), September 2013).

67 M. Coddington et al., "*Updating Technical Screens for PV Interconnection*" (Austin, Texas: Institute of Electrical and Electronics Engineers (IEEE), June 2012).

4. NET METERING IN PAKISTAN: SITUATION ANALYSIS

Given the high cost of electricity, excessive system losses and above average solar insolation levels in most of the country's land area, distributed power generation, particularly from solar PV, has the potential to achieve substantial scale in Pakistan. In addition, DG from renewable resources can deliver clean, sustainable and indigenous electricity to the national grid, reducing the country's energy import dependence. Strategically placed DG can also alleviate congestion on the network and provide voltage support to the distribution grid (see **Annex-1** for more details on the benefits of DG from renewable resources). Recognizing the advantages of grid connected DG, the Government of Pakistan included net metering in the country's RE policy (*Policy for Development of Renewable Energy Power Generation, 2006*), enabling the regulator to adopt comprehensive net metering regulations in 2015 (*Alternate and Renewable Energy, Distributed Generation and Net metering Regulations, 2015*). Growth in net metered installations has however been markedly slow, with only 815 licenses issued by December 2018, adding 17.28 MW to the country's installed solar capacity.[68]

This section of the report evaluates the policy, regulatory and market issues limiting net metering growth in Pakistan. The objective of the analysis is to provide a basis for future interventions to support net metering and ensure that the recommendations made by this report are effective in addressing local barriers to net metering proliferation. By reviewing net metering support programs implemented by AEDB and international development organizations, the analysis will also help avoid duplication or overlap between net metering initiatives by various entities.

4.1 LOCAL CONTEXT

The electricity network in Pakistan delivered 99609 GWh of energy in 2016-17 from an installed generation capacity of 28400 MW. The per capita electricity consumption in the country during the period was approximately 480 kWh; in comparison, India and China's per capita consumption in 2014 was 805 kWh and 3927 kWh respectively. Generation capacity in Pakistan frequently falls short of demand, leading to forced outages. The most recent capacity shortfall began in 2012 and lasted five years until 2017 with power shortages during the period reaching 6328 MW or 22% of peak-demand. In addition, while the electricity supply network covers a significant portion of the country, the infrastructure is weak or inadequate in many locations and upgrades are considered necessary to improve the reliability of power supply and reduce system losses. The distribution grid comprises ten state-owned distribution companies or DISCOs and the privately owned K-Electric. [69]

4.1.1 RETAIL ELECTRICITY TARIFFS

Electricity rates for residential consumers in Pakistan are based on an ascending block-rate structure, with added rate differentiation for 3-phase customers (Time-of-Use or ToU rates). Residential customers are classified in two different 'tariff categories' based on sanctioned load - 'above 5kW' and 'below 5kW' - with six tariff-slabs or blocks defined within the first load category and a uniform ToU tariff applied to the second load category. Commercial and industrial electricity consumers are classified into three and four tariff categories respectively, based on sanctioned load. Consumers in all three market segments are also required to pay a minimal fixed or demand-based monthly charge.

Residential customers consuming less than 300 kWh of electricity each month and all agricultural customers receive a tariff subsidy while residential customers using more than 300 kWh a month and all commercial and industrial customers pay unsubsidized tariffs and are subject to an additional tariff surcharge that varies by tariff slab or category. As a result, residential electricity tariffs vary significantly

[68] Dr. Irfan Yousaf, Director, AEDB

[69] NEPRA, "*State of the Industry Report 2017*" (Islamabad, Pakistan: National Electric Power Regulatory Authority (NEPRA), 2017).

between tariff blocks and can range from Rs.2.00 (US cents 1.4) per kWh to Rs.20.00 (US cents 14) per kWh. Representing approximately 15% of the DISCO customer base, high-tariff consumer categories or tariff blocks cross-subsidize electricity consumption by low-volume, low-income residential and all agricultural consumers.

Net-metering in Pakistan is currently allowed to 3-phase electricity customers only, effectively limiting the market for net-metering to un-subsidized residential and all commercial and industrial electricity consumers connected to the state-owned DISCOs and K-Electric. **Table 4.1** summarizes tariffs applicable to electricity customers eligible for net-metering on the IESCO grid.

Table 4.1: Tariffs Applicable in the IESCO Service Area to Electricity Consumers Eligible for Net-metering [70]

Market Segment	Variable charges Rs./kWh (US cents/kWh)	Fixed charges Rs./kW/Month (USD)
Residential (sanctioned load above 5kW)		
Time of Use (Peak)	20.70 (15.00)	None
Time of Use (Off-peak)	14.38 (10.00)	
Commercial (sanctioned load above 5kW)		
Regular	19.68 (14.00)	400 (2.86)
Time of Use (Peak)	21.60 (15.00)	400 (2.86)
Time of Use (Off-peak)	15.63 (11.00)	
Industrial		
B1	15.28 (11.00)	
B1 (Peak)	18.84 (13.00)	
B1 (off-peak)	13.28 (9.50)	
B2	14.78 (11.00)	400 (2.86)
B2 (Peak)	18.78 (13.00)	400 (2.86)
B2 (off-peak)	13.07 (9.30)	
B3 (Peak)	18.78 (13.00)	380 (2.72)
B3 (off-peak)	12.98 (9.30)	
B4 (Peak)	18.78 (13.00)	360 (2.58)
B4 (off-peak)	12.88 (9.20)	

Given the current tariff and taxation regime in Pakistan, residential electricity customers paying unsubsidized tariffs and all commercial and industrial consumers can derive some economic benefit from generating electricity on-site, at a lower cost than grid-supplied power. Since industries benefit more from self-consumption than supplying electricity to the grid, net metering policies will be more effective in promoting DG in the high-consumption residential and commercial market segments.

70 IESCO website: Tariff Schedule notified on January 1, 2019. Conversion rate: 139.80 Pak. Rupees to 1 USD.

4.1.2 POTENTIAL MARKET FOR NET METERING

Since net-metering regulations in Pakistan allow only 3-phase electricity customers to participate in the net-metering program, the potential market for net-metering is limited to approximately 882, 707 customers, including 371,060 residential, 150,927 commercial and 360,721 industrial electricity consumers, or approximately 3% of all grid-connected electricity customers in the country.[71] Although the potential market is small compared to the grid's customer base, these customers consume approximately 35% of all electricity delivered by the distribution grid and provide more than 40% of all revenues collected by public and private the distribution companies (see **Figure 4.1** and **Figure 4.2** below). [72] Since customers eligible for net-metering pay the highest tariffs and cross-subsidize low-income consumers, wide-scale adoption of DG or net-metering could lead to a reduction in subsidy collection, undermining the current subsidy regime in Pakistan.

Figure 4.1: Electricity Consumption by DISCO Customers in Pakistan
(Total consumption: 97197400 MWh)

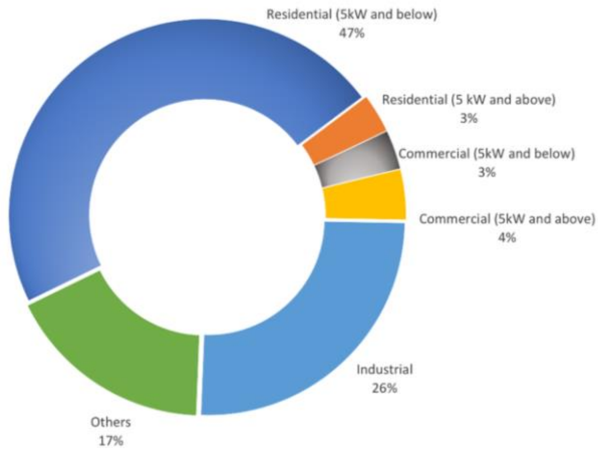
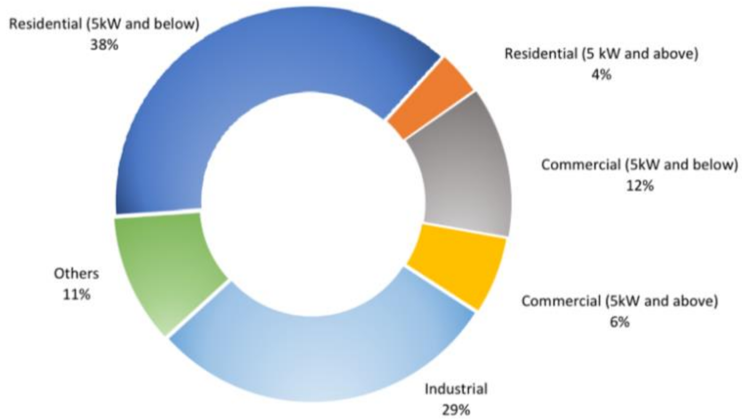


Figure 4.2: Revenue Generation from DISCO Customers in Pakistan
(Total revenue: 1,087.6 Billion Pak Rupees or 7.8 Billion USD)



Given the low cost of energy generated from roof-top solar installations (see **section 4.14** for more details) and the rising cost of the tariff subsidy, government funded DG systems could provide an effective lower-cost alternative to electricity tariff subsidies. A detailed cost-benefit analysis would be

71 PEPCO (2018), DISCOS Performance Statistics, Pakistan Electric Power Company (Pvt) Limtied (PEPCO), June 2018 and NEPRA (2017), State of Industry, 2017. These figures include customers of state-owned DISCOs and K-Electric. The figures for each customer segment within K-Electric are approximated from customer distribution in the state-owned DISCOs.

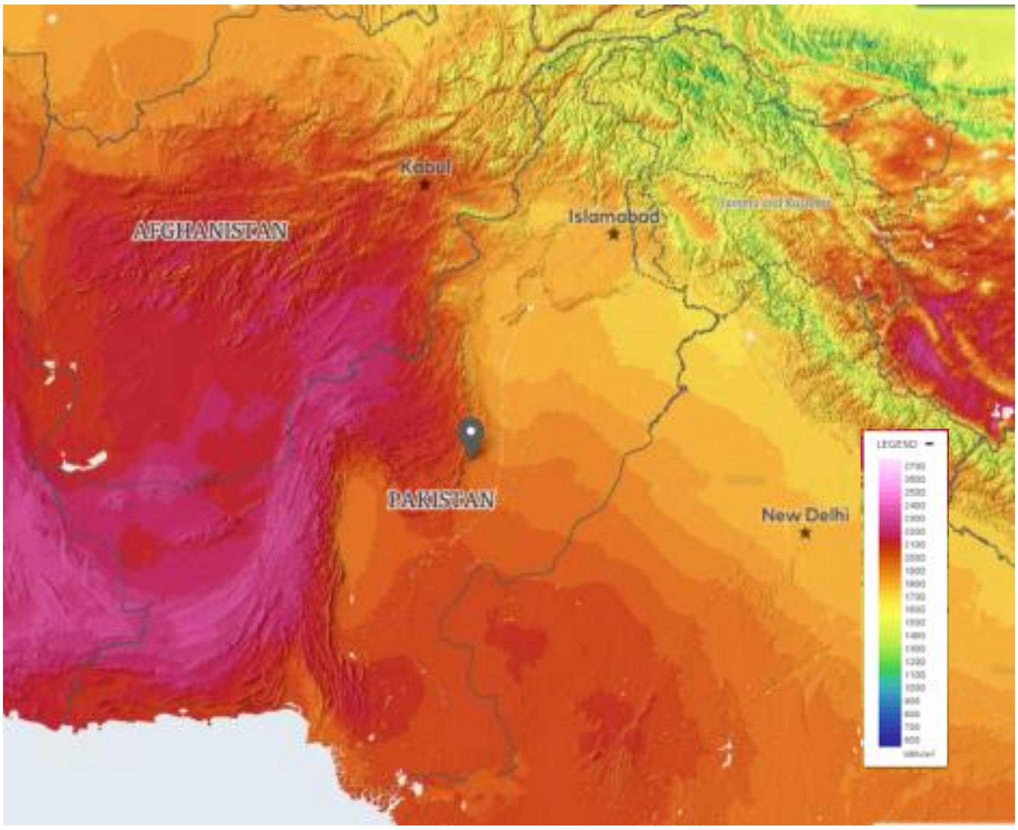
72 PEPCO (2018)

required to determine the exact impact of DG and net-metering on low-income, low-use residential electricity consumers and gauge the potential of government funded DG systems to reduce electricity subsidies.

4.1.3 RESOURCE AVAILABILITY AND COINCIDENCE WITH PEAK DEMAND

Solar irradiance levels recorded in most of Pakistan exceed global irradiance averages. Estimated peak irradiance values in western Baluchistan province are over 2700 kWh per square meter per year, while 83% of the land area exceeds the threshold values of 2000 kWh/m^2 and 3,000 hours of sunshine a year. The estimated irradiance values only decrease gradually from south to north and exceed 1500 kWh/m^2 per year in more than 90% of the land area[73].

Figure 4.3: Global Horizontal Irradiation (GHI) Levels in Pakistan *(globalsolaratlas.info)*

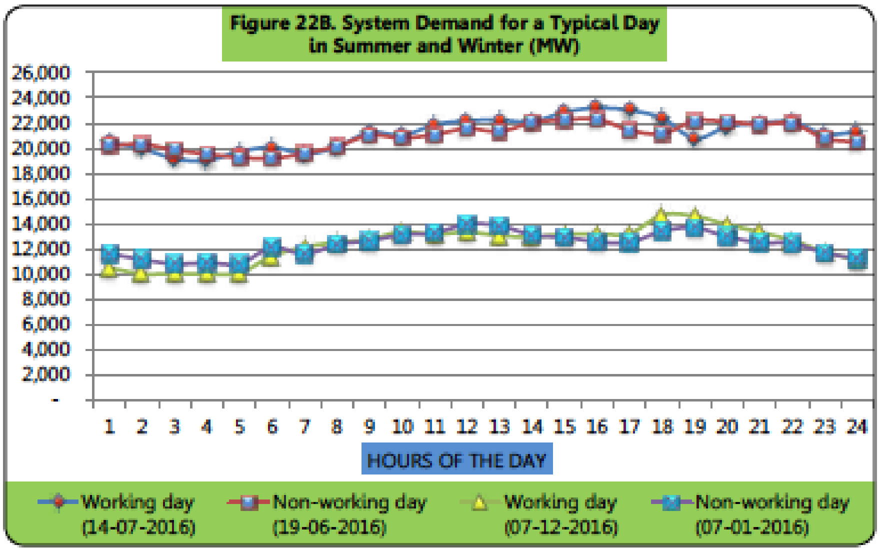


Solar irradiance levels are highest in the south and south-west of the country (see **Figure 4.3** above), however even regions with relatively lower levels of solar resource have a better insolation profile than Germany, the largest distributed PV market in the world [74]. Consumption or demand peaks occur in the evenings between 4 to 6 pm during summers and 6 to 8 pm in winters. Although peak solar insolation is not coincident with peak-demand, there is significant potential for replacing expensive day-time generation (between 10 am and 2 pm) with low-cost, solar power (see **Figure 4.4**).

[73] World Bank-ESMAP, "*Renewable Energy Resource Mapping Pakistan*", 2014, www. esmap.org/re_mapping_Pakistan.

[74] Umar Mustafa, Tobias Marz, and Gerwin Dreesmann, "*Roadmap for the Rollout of Net Metering Regulations in Pakistan*" (Lahore, Pakistan: GIZ, September 2016).

Figure 4.4: Electricity System Demand for in Pakistan for a Typical Day in Summer and Winter (MW)[75]



4.1.4 ROOFTOP PV COSTS AND GRID-PARITY

The capital costs of net metering installations in Pakistan in all three market segments - residential, commercial and industrial - are competitive with global costs for roof-top solar PV (see Table 4.1). In addition, the levelized cost of electricity (LCOE) for all unsubsidized electricity consumers is at or below grid-parity, with electricity from rooftop PV costing less than the rates of unsubsidized electricity in most parts of the country.

The LCOE and capital costs in **Table 4.2** are based on primary market research and are indicative of current market prices for rooftop solar PV systems. The un-discounted payback period for a 5 kW residential solar system is approximately 3.7 years and could decrease further if panel prices fall or electricity tariffs rise. The payback period for typical commercial and industrial systems varies between 3 and 5.9 years (see **Annex 4** for detailed assumptions used in the financial model for LCOE and payback calculations). Consumers in the industrial and commercial market segments also have the option of entering into a Power Purchase Agreement (PPA) with third-party solar installers, securing a 12 to 15-year contract for energy delivery.

The LCOE and capital costs in Table 4.2 are based on primary market research and are indicative of current market prices for rooftop solar PV systems.[76] The un-discounted payback period for a 5 kW residential solar system is approximately 3.7 years and could decrease further if panel prices fall or electricity tariffs rise. The payback period for typical commercial and industrial systems varies between 3 and 5.9 years (see **Annex 4** for detailed assumptions used in the financial model for LCOE and payback calculations). Consumers in the industrial and commercial market segments also have the option of entering into a Power Purchase Agreement (PPA) with third-party solar installers, securing a 12 to 15-year contract for energy delivery.

[75] NEPRA, "*State of the Industry Report 2017.*"

[76] Florida PUC, "Rule- 25-6.065 Interconnection and Net Metering of Customer-Owned Renewable Generation" (Florida Public Service Commission, July 4, 2008). Financial modelling based on the SANDIA Labs engine.

Table 4.2: Indicative Figures for LCOE and Capital Costs in the Residential, Commercial and Industrial Roof-top Solar Market Segments[77]
(All Figures Based on Primary Research and Levelized Over 25 years)

	Residential Installations	Commercial Installations	Industrial Installations
System size	5kW	43kW	1MW
Levelized Cost of Electricity (per kWh)			
LCOE (Real)	PKR 8.47 (US Cents 6.00)	PKR 5.76 (US Cents 4.10)	PKR 5.48 (US Cents 3.91)
LCOE (Nominal)	PKR 14.48 (US cents10.3)	PKR 9.85 (US cents 7.04)	PKR 9.38 (US cents 6.71)
Capital cost (per kW)	PKR 105,000 (USD 751)	PKR 85,000 (USD 608)	PKR 80,000 (USD 576)
Payback (simple)	3.7 years	3 years	3.8 years
Payback (discounted)	5.2 years	3.7 years	5.2 years

4.1.5 PERFORMANCE OF THE TRANSMISSION AND DISTRIBUTION NETWORKS

In its current state, the transmission infrastructure in Pakistan was barely adequate to serve the load in 2018. Losses in the transmission system are high in comparison to global standards and the transmission network recorded 126 'loss of supply' incidents in 2016-17 alone, causing major interruptions in electricity supply. Ranging from 9.03% to 32.6 %, losses on the distribution network are excessively high, leading to chronic revenue deficits at the DISCOs.

Constrained by high system losses and low revenue recovery rates, DISCOs are generally reluctant to take on the perceived revenue loss from electricity consumers installing net metering systems. The capacity of the DISCOs to assess and quantify the positive impacts of DG on system losses and administer net metering programs is also limited, leading to misconceptions around the impacts of DG and delays in application processing.

The ability of strategically placed DG systems to reduce distribution losses provides a strong justification for net metering in a country such as Pakistan, where average T&D losses are close to18%.[78] The transmission and distribution system constraints in Pakistan represent an opportunity where net metering could potentially alleviate some of the issues in system operation. For instance, since small, distributed generators connect to the grid at the distribution (or sub-transmission voltage) level, ingesting power close to load centers could help reduce transmission and distribution losses in the system, incurred when delivering power over long distances from centralized generators located far from the load centers.

77 Step Robotics, 2019; The simulations were run by the Islamabad based technology startup, Step Robotics, using Islamabad, Pakistan as the project location on the SANDIA LABS simulation engine. The simulation assumes an energy settlement only and does not account for any commercial settlement (cash compensation) for Net Excess Generation (NEG). See **Annex 4** for detailed modelling assumptions associated with each market segment.

78 NEPRA, "*State of the Industry Report 2017.*"

Net metered DG can also deliver several other benefits to DISCOs. For instance, in some locations on the distribution grid, net metering could decrease network congestion or provide additional power to eliminate or reduce forced interruptions in electricity supply. Suitably placed DG or net metered systems can also aid voltage regulation on the network, especially in locations where feeders are over-loaded.

4.1.6 ADDITIONAL FINANCIAL INCENTIVES

Pakistan allows duty-free imports of renewable energy equipment including solar panels, inverters and batteries etc. This translates into a significant cost reduction at the wholesale and retail levels and helps drive down the LCOE associated with net metered installations. There are no additional fiscal or financial incentives available for net metering installations.

4.1.7 QUALITY AND SAFETY STANDARDS

Pakistan adopted IEC quality, safety and environmental standards as 'Pakistan Standard' in 2015 however there is no single agency responsible for enforcing these standards across the supply chain, resulting in frequent quality lapses. AEDB is implementing various programs to address quality control issues and improve the standard of both net metering equipment and services through process automation and other mechanisms (see **Section 4.3** for details).

4.1.8 MARKET STRUCTURE

The market for net metering is predominantly urban and caters mostly to demand from the residential segment. The proliferation of DG products and services is following the pattern of DG growth in other emerging market countries such as Brazil, where incomes, population and electricity tariff levels are the primary determinants of DG technology uptake[79].

Several small and mid-sized PV system integrators (known as installers, solar companies or solar system providers in Pakistan) design and install net metering systems through a service-provision model. At the high end of the market, these companies offer a full suite of Engineering, Procurement and Construction (EPC) services and post installation operation and maintenance (O&M) support. Service delivery at the low end of the market is limited to system-sizing, equipment installation and after-sales support for a limited period (typically one year).

Local manufacturing of solar equipment is limited to solar-panel assembly and manufacturing of AGM batteries by local industrial groups, including Daewoo. Treet, Eco Star (DWP and Gree) and Homage. Solar companies or installers rely mainly on imports for fulfilling orders. The supply chain consists of equipment importers, wholesalers and retailers that provide equipment including solar panels, inverters, batteries and charge controllers to the installation companies. Chinese solar equipment has the largest market share in Pakistan with more than 90 % of PV panels and over 80 % of deep-cycle batteries imported from China. The dominance of Chinese imports is partly due to the price-competitiveness of the products, however extensive dealership networks and product selection also plays a role; Chinese equipment is available at a wide variety of price-points, corresponding to different quality levels and can therefore cater to a much broader customer base. Other countries supplying solar equipment to the local market include Germany, Hong Kong, UAE, Malaysia, UK, Finland, Italy and others.

[79] Juliano Assunção and Amanda Schutze, "*Developing Brazil's Market for Distributed Solar Generation*" (Climate Policy Initiative, September 2017).

4.2 KEY ISSUES

4.2.1 WEAKNESSES IN THE POLICY, LEGAL AND REGULATORY FRAMEWORK

1 - Pakistan's current RE policy lapsed in 2018 with no clear indication of whether net metering will receive policy cover under a new policy regime

The Government of Pakistan's (GoP) most recent energy policy, the National Power Policy 2013 covers a broad spectrum of activities in the power sector, including solar, wind and bagasse power generation projects, however, the policy makes no specific mention of DG or net metering from renewable resources. The only policy direction for net metering comes from the *Policy for Development of Renewable Energy for Power Generation 2006* (the 2006 RE Policy). Section 8.4.2 of this policy relates specifically to net metering, providing the following guidelines for electricity generation from net metered systems[80]:

- RE power projects of 1 MW or less capacity, set up for self-consumption (captive use) or dedicated use may also supply surplus electricity to the power utility while at other times drawing electricity from the utility to supplement its own production for local use.
- The net electricity supplied by the power producer to the utility in a month is equal to units supplied by the producer minus units received by the producer, if greater than zero, or the net electricity supplied by the utility to the power producer in a month, i.e., units received by the producer minus units supplied by the producer, if greater than zero, shall be paid for by the utility or the producer, respectively, at the applicable retail tariff (e.g., industrial, commercial, or residential rates).
- Such net metering arrangements may involve separate sets of unidirectional meters for recording the electricity received and supplied to the utility by the power producer, or special bidirectional meters capable of instantaneously recording net power transfers. This facility would be particularly suitable for incentivizing dispersed small-scale RE generation, such as rooftop PV panels, helping optimize their utilization and payback rates and obviating the need for expensive on-site storage batteries.

The 2006 RE policy lapsed in 2018, following which, there is no applicable policy in Pakistan for net metering.

2 – The current net metering regulations do not reflect the changes in the NEPRA Act that could benefit electricity customers with net metering installations

The regulatory law applicable to the provision of electricity in Pakistan, the NEPRA Act, also applies to DG and net metered installations. The NEPRA Act was recently amended (Act 2018), to modify the previous version of the act (Act 1997). Several changes in the new law have implications for DG and net metering:

- *Exemption from the generation license requirement* - In Act 1997, all power generation facilities expecting to sell electricity to another entity were required to obtain a power generation license from the regulator. This included net metering systems that sold surplus power to their host DISCO. *Section 14 B (5)* of Act 2018 however makes an allowance for the Federal Government (in consultation with NEPRA) to withdraw the generation license requirement for certain types of generators as early as 2018. Under the new act, no new power generation facility will require a generation license post 2023 (the date set for market de-regulation in Pakistan). In addition, *Section 2(ii-a)* of Act 2018 designates power plants set up by housing co-operatives or 'association of persons' as captive generating plants and Section 2(xi) and also exempts these from the generation license requirement.

  Small RE based generation facilities, particularly residential solar generators and captive power plants, would be good candidates for immediate exclusion from the mandatory license

80 Government of Pakistan, "*Policy for Development of Renewable Energy for Power Generation, 2006*", 2006.

requirement. Exemption from the license requirement would simplify the net metering installation process and enable consumers with net metering to sell surplus power outside the jurisdiction of their host DISCO.

- *Electricity sale to third-party consumers* - The Act 2017 allowed third-party ownership of generating facilities however, DG systems were restricted to selling electricity only to the host DISCO. *Section 14C(2) and Section 2(ii a*) of Act 2018, makes it mandatory for the host DISCO to provide all captive generators (including DG facilities set up by consumers, housing co-operatives and/or associations) access to the distribution grid, for sale of electricity to third-party consumers.

Despite the provision for an exemption in the new Act 2018, the net metering regulations in Pakistan continue to require generation licenses for all DG systems, regardless of size or capacity, and disallow the sale of electricity to a third party.

Table 4.3 and **Table 4.4** compare net metering regulations and interconnection standards in Pakistan (as of September 13, 2018) with the global 'best-practice' described in **Section 3**. For better illustration, the best-practice overview in **Section 3** is supplemented with specific examples from Sri Lanka, the Philippines, the state of Florida in the USA and Maharashtra in India, where net metering programs have been implemented successfully (Florida) or the electricity market structure and economy are similar to Pakistan (Maharashtra, the Philippines and Sri Lanka).

Although the net metering regulations in Pakistan generally maintain a fair balance between the interests of the DISCOs, net metered electricity customers and customers without net metering, there are improvements that can be made to make net metering easier to implement and more accessible for electricity consumers:

3 – Net metering regulations are missing local-level caps, include no provisions for information sharing between the DISCOs and the regulator and allocate all equipment and interconnection costs to consumers

- The amount of DG that can be safely integrated in the distribution grid depends on the distribution system configuration and diversity of consumers at the DT level. It is therefore important to establish a local-level cap at the DT, especially where grid-infrastructure is weak or inadequate and upgrades might be required to accommodate high levels of DG penetration.
- The cost of bi-directional meters and interconnection contributes significantly to the system installation costs and impacts the affordability of net metered systems, especially for small residential electricity consumers.
- The DISCOs are not required to share any information about the net metered systems on its network. Regular information sharing between the DISCO and the regulator regarding the number of net metered connections added to the DISCOs network, the units of electricity purchased from net metered installations and payments made against net-excess generation to net metered customers would allow the regulator to better manage the program and make timely adjustments.

Table 4.3: Net Metering Regulations: Design Elements and Regulatory Best-practice[81]

Design Element	Regulatory Best-Practice	Pakistan	Florida (USA)	Maharashtra (India)	Sri Lanka	Philippines
Metering & Billing Arrangement	Traditional net metering (compensation at retail rates) is a relatively simple compensation mechanism for DG system owners and DISCOs to implement and more effective in nascent markets	Net metering	Net metering	Net metering	Net metering The program offers three variations: 1. Net metering 2. Net-accounting (or net-billing) 3. Net-Plus (Direct sale to DISCO) Options 2 and 3 are available for Solar PV systems only.	Net metering
Sell Rate Design *(Compensation for electricity produced during the netting period)*	In nascent markets, compensation at retail rates i.e. the meter spins backwards	For electricity exported to the grid during the netting period, the energy compensation rate is the same as the one at which the consumer is billed (Peak against peak and off-peak against off-peak rates)	Offsetting customer's consumption allowed. Peak off-peak not specifically mentioned	Peak off-peak not specifically mentioned but ToU metering allowed to consumers billed under a ToU arrangement.	Peak off-peak not specifically mentioned.	Adjustment of bills based on export/ import.

[81] Florida PUC, "Rule- 25-6.065 Interconnection and Net Metering of Customer-Owned Renewable Generation"; Maharashtra Electricity Regulatory Commission, "Net Metering for Rooftop Solar Systems Regulations 2015," n.d.

Design Element	Regulatory Best-Practice	Pakistan	Florida (USA)	Maharashtra (India)	Sri Lanka	Philippines
System Size Cap	Higher system size caps coincide with accelerated market transformation and greater installed capacity. Technical constraints at local distribution transformer level need to be accounted for	1 MW	2 MW	0.8 MW	Limited to the contracted demand of a consumer	0.1 MW
Capacity limit based on customer load	Typically limited to between 100% to 150% of customer load	150% of the customer's sanctioned load	90 % of Customer's service rating.	100 %	100 %	No specified limit
Local level cap	Limit on grid-penetration at 15% of distribution transformer capacity is recommended in the first phase of net metering programs, especially where infrastructure upgrades might be required to accommodate high levels of DG penetration.	No local level cap specified	No limit	40 % of Distribution Transformer capacity. DISCOs can allow higher limit if system studies permit.	No limit	No limit
Netting Frequency and Credit Reconciliation Period *(Roll over period)* *for Net Excess Generation or NEG*	Traditionally longer netting and reconciliation periods are more advantageous for customers as seasonal variation in production and consumption allow for maximum netting. Cyclic net metering (credit reconciliation after a pre-determined period e.g. 3 months) and Perpetual roll-over are the two most common approaches for reconciling and crediting net excess generation	Netting frequency: Monthly (30 days) Credit reconciliation period: (or cycle): 3 months	one month	one month	For net metering: NEG rolled over to the next month until contract termination	Net Adjustment rolled over to next month
Crediting Terms *(type and amount of compensation paid at*	NEG is not compensated or compensated at a rate less than the retail price of electricity.	Cyclic net metering with commercial settlement	Adjustment roll over to next month for one year. At the end of	Adjustment rollover to next month for one year. At the end of	For net-accounting, credit for excess generation paid at	Perpetual credit roll-over

Design Element	Regulatory Best-Practice	Pakistan	Florida (USA)	Maharashtra (India)	Sri Lanka	Philippines
the end of the credit reconciliation period)	Compensation can be provided as energy credit (energy settlement) or cash compensation (commercial settlement)	(cash compensation) after every three months OR Perpetual roll-over The rate paid for electricity produced at the end of the credit reconciliation period (NEG) is equal to the National Average Power Purchase Price (PPP) for DISCOs, aggregated for the billing period, as determined by the regulator.	each calendar year, any NEG will be payable by the DISCO at the average annual sale tariff	each financial year any net energy credit will be payable by the DISCO at the average power purchase cost	Rs.22.0 per unit for first 7 years and Rs.15.50 per unit for next 13 years No payment for any net energy credit upon termination	Rate paid for NEG is based on the DISCO's blended Generation purchase cost
Cost of Interconnection arrangement and metering	Customer pays the cost. However, examples exist of DISCOs paying for the costs and recovering the expense through an additional charge applied to the monthly electricity bills of net metered customers	Customer pays the cost	The DISCO pays the cost Cost of additional meters required for claiming RECs to be borne by the customer	DISCO responsible for specifications, supply, installation and testing cost of interconnection and metering arrangement.	Customer pays the cost	DISCOs pay but are allowed to recover the cost from consumers through a monthly net metering charge added to electricity bills

4 – Interconnection standards are ambiguous on several accounts

Interconnection for Renewable Generation Facilities Regulation, 2015 (IC Reg 2015) is the applicable interconnection standard for net metered installations in Pakistan. Although the interconnection standards comply with many of the best-practices described in **Section 3.3,** there are deficiencies that need to be addressed:

- The regulation specifies an interconnection at 11 kV for systems between 500 kW to 12.5 MW, however, interconnections at a voltage less than 11 kV or load less than 500 kW are not addressed. Since most net metering systems, particularly residential and commercial installations, are less than 500kW and connect to the distribution network at 0.4 kV, this is an important omission the interconnection rules.
- Customers applying for net metering require approval from the host DISCO or transmission network operator on simulation studies. However, the responsibility for carrying out simulation studies is not prescribed to a particular entity; It is not clear whether the simulation study is to be carried out by the DISCO or by the net metered customer (through an independent third-party).
- The Standard Operating Procedures (SOPs) followed by the DISCOs when processing applications are not clearly defined. Each DISCO has therefore developed its own processes, creating complications for system installers working across the jurisdictions of multiple DISCOs.

Table 4.4: Interconnection Regulations: Design Elements and Regulatory Best-practice[82]

Design Elements	Regulatory Best-Practice	Pakistan	Florida (USA)	**Maharashtra** (India)	**Sri Lanka**	**Philippines**
Time taken to execute an Interconnection agreement (IA)	'Express' processing for systems less than 10kW and expedited processing for all other system sizes	57 days to sign agreement, 15 days for Regulator to grant license and another 50 days for installation & commissioning of Interconnection.	40 days for = <100kW. 90 days if system study is required. Initiation of NM within 30 days of signing IA.	52 days (including 15 days taken for testing, commissioning and approving IA and excluding time taken by applicant to install system within his premises).	No Limit Solar plants to be connected with Grid within 2 weeks of application	Mutually agreed between HDC and DGNM. No time limit specified by regulator.
Generation License requirement	Not required	Generation license required. Under a simplified license procedure. After agreement with DISCO Regulator takes average of 15 days to grant license or any exemptions required.	Not required.	Not required.	Not required.	Not required.
System study requirement	Not required for systems below 10kW	According to the regulations, system studies are required for renewable energy-based DG installations connecting to a DISCO or Transmission company. However, the DISCOs have independently opted not to conduct system studies for Net Metered installations with a capacity of less than 250kW	Not required for 100 kw or less.	Not prescribed. A DISCO can disconnect if it finds Customer responsible for any damage or adverse effects on DISCO system or other consumers.	Not prescribed.	At the discretion of the host DISCO

82 Florida PUC, "Rule- 25-6.065 Interconnection and Net Metering of Customer-Owned Renewable Generation"; Maharashtra Electricity Regulatory Commission, "Net Metering for Rooftop Solar Systems Regulations 2015."

Design Elements	Regulatory Best-Practice	Pakistan	Florida (USA)	**Maharashtra** (India)	**Sri Lanka**	**Philippines**
Standard Interconnection agreement (SIA)	Specified	Yes, specified in Regulations.	Approved by the regulator for each DISCO	specified	specified	specified
Inter connection Standard and Conformance Test procedure	IEC, IEEE 1547 standards	IEEE 1547, IEC, EN or other International applicable standards. Approval of HDC required before allowing interconnection.	IEEE 1547 IEEE 1547.1 Under writer Laboratories (UL) 1741 Inspection and approval by Local Code implementation officials.	Technical standards for connectivity specified by Central Electricity Authority (CEA).	IEEE 1547 IEC 61400-21 Quality of supply) 61000-3-7	Standards specified by Regulator, based on IEC and IEEE Quality and Safety standards.
Certification for allowing interconnection	Required	Interconnection testing certification by Electrical Inspector and commissioning test carried out by host DISCO before allowing interconnection	Certification by Nationally recognized testing laboratory	Testing, Certification by host DISCO	Testing/ Certification to be carried out by Consulting Chartered Electrical Engineer and witnessed by host DISCO's engineer	Commissioning tests witnessed and approved by host DISCO
Automatic Isolation of Generation equipment in case of Loss of Power	Required	Required based on IEC, IEEE standards.	Required	Required	Required	Required. Minimum time limits for disconnection specified.
Interconnection Manual Disconnect Switch, with visual disconnect	Required	Required	Required	Required	Required	Required

4.2.2 LACK OF A MARKET ROLL AND IMPLEMENTATION PLAN

In the absence of an implementation plan or clear objectives, the net metering policy is unlikely to achieve results. Policy makers need to address several key considerations related to program roll-out; starting with a restricted or pilot program, assessing financial and technical impacts on DISCOs and providing clear indication of a transition from net metering or adjustments to the current regulations. An implementation plan brings transparency to net metering programs and allows stakeholders to better prepare for eventualities arising from net metering uptake.

4.2.3 BARRIERS IN THE MARKET ENVIRONMENT

Compensation policies such as net metering incentivize private investment in DG by improving the economic returns from these investments and reducing the associated risks. However, electricity customers considering investments in DG must contend with several other challenges related to the local market environment, for instance, limited access to debt, a lack of diversity in business models and limited institutional capacity of the DISCOs to implement a net metering program. Net metering policies do not account for these barriers or mitigate the risks associated with them. Additional measures, such as capacity building of key institutions, provision of concessional finance and reduction of 'soft-costs' through market pull strategies are often required to remove barriers to the growth of DG[83].

The slow growth of grid-connected DG in both China and India highlights the relevance of the enabling environment, particularly in emerging markets. Both countries have been unable to develop the DG market as intended, despite providing targeted policy support and financial subsidies to the sector (see **Section 2** for details on the typical barriers to DG growth in emerging markets). The net metering market in Pakistan is limited by several issues common to other emerging market countries:

1 - High up-front costs and a lack of financing options make net metered systems unaffordable for most electricity consumers

Although the LCOE of roof-top solar systems is significantly lower than grid-supplied electricity, net metered installations are capital intensive and require up-front investment in equipment, labor and permitting costs. Despite the potential for savings on electricity bills, the high upfront cost of the systems makes them un-affordable for most electricity consumers and inhibit growth in the net metering market, A lack of innovative business models based on net metering and the reluctance of local banks to lend to small DG projects aggravates the situation further. See section 4.1.4 for details.

2 – The distribution companies have limited resources and administrative capacity to effectively manage the net metering program

As the only power purchasers in the country, public and private distribution companies are a major stakeholder in the net metering market and impact every stage of the net metering application and installation process. The capacity of the DISCO to administer and manage net metering installations is therefore a key pre-requisite for market growth. DISCOs in Pakistan are managing the net metering program with varying degrees of success, however, progress in increasing the net metering uptake is slow overall and could benefit from capacity building at the distribution companies.

3 – Some distribution companies are reluctant to support the net metering program due to concerns around revenue loss

Distribution companies generally equate an increase in net metered installations with reduction in DISCO revenue; self-consumption from the DG installation replaces power purchased from the distribution grid, hence impacting the revenue earned by the distribution company. In Pakistan however, the distribution system is severely constrained and could benefit from increasing DG installations. Since small, distributed generators connect to the grid at the distribution level, ingesting power close to load centers could help reduce distribution losses in the system. In some locations on

83 Azuela and Barroso, "*Design and Performance of Policy Instruments to Promote the Development of Renewable Energy-Emerging Experience in Selected Developing Countries*."

the distribution grid, net metering could decrease network congestion or provide additional power to eliminate or reduce forced interruptions in electricity supply. Suitably placed DG or net metered systems can also aid voltage regulation on the network, especially in locations where feeders are overloaded. Revenue loss will only become an issue for DISCOs once DG penetration on the distribution grid reaches a significant level and increasing DG can longer deliver technical benefits to the system.

4 – The installation process is unnecessarily complicated

The interconnection rules allow almost four months for net metering installation, from application submission to system interconnection. The actual installation process takes even longer and can extend beyond eight months. The process involves multiple steps and several entities and is difficult for the average electricity customer to navigate without professional support from system installers.

5 – Most consumers are unaware of the benefits of net metering or consider the technology ineffective and unreliable

Most electricity consumers are either unaware of the net metering program or consider the technology un-proven. AEDB has implemented several initiatives to reduce the risk perception around net metering systems; Installation companies are required to register with AEDB and only AEDB certified installers are authorized to set up net metering installations on a DISCOs network. In collaboration with GIZ, AEDB is also developing an installer verification scheme called PV passport. The benefits of net metering and the risk reducing initiatives by AEDB and others need to be publicized among consumers.

6 – Roof-top space is not always available or adequate for solar PV installations

Commercial net metering customers located in rented spaces or those requiring more space for roof-top generation than available at their own premises should have the option of wheeling electricity from a separate generation location (either their own or maintained by a third-party provider) under a net metered arrangement. Although the NEPRA Act 2018 makes provisions for wheeling and NEPRA has issued regulations to develop the wheeling market, DISCOs are generally reluctant to support business models around wheeling.

- Based on the perceptions and experiences of solar installers and distribution companies in Pakistan[84], the barriers to net metering growth and their relative impact are summarized in **Table 4.5**.

Table 4.5: Market Barriers to Net Metering Growth in Pakistan

Barriers in the Enabling Environment for Net Metering	Low	Moderate	High
High upfront capital cost of system and limited access to debt financing for small distributed PV installations			●
Limited capacity of the distribution companies to administer the program			●
Resistance from power sector incumbents such as distribution companies and system operators	●		
Lack of awareness about the net metering program among power consumers and Consumers perception of technology and performance risk			●
Complicated process for subscribing to Net metering			●
Limited availability of rooftop space (particularly for the commercial and industrial segment)		●	

84 Primary reserach based on a consultation with members of the Renewable Energy Association of Pakistan (REAP), meetings with DISCOs and interviews with individual service providers (installation companies and others). Conducted between August and December 2018.

4.3 CURRENT NET METERING SUPPORT PROGRAMS

The AEDB has implemented several interventions in collaboration with the German development organization, GIZ and others, to address the barriers limiting net metering proliferation in Pakistan:

- **PV Passport**: A joint project of the German Solar Association (BSW-Solar) and Frankfurt School of Finance & Management, commissioned by GIZ, PV passport is a certification procedure for PV systems. The State Bank of Pakistan has been offering loans for the financing of PV systems since 2016 however, private banks rarely incorporate these loans into their financing products for investments in photovoltaics, as banks often lack the necessary understanding of the technology and of the associated business models. The project will also organize training seminars for banks, offering courses by the Frankfurt School of Finance & Management to financing experts from three participating commercial banks in Karachi. The training provided will assist financial professionals to learn how to assess private and commercial photovoltaic projects with the help of a yield calculator. The project is expected to run until September 2019.

- **Pakistan Distributed Generation Roadmap:** GIZ is conducting a technical and financial impact assessment of net metering on the IESCO system. The assessment will include an in-depth analysis of the IESCO system and assess the potential impacts of economic, technical and social integration of DG (PV and wind) based on qualitative and quantitative analysis, with a focus on net metering and nodal or spatial auctions. Project components include:

    1. Economic analysis for optimal VRE scaleup roadmap through the proprietary RECD modelling package by developed by Development
    2. Technical analysis to determine technical limits to DG PV growth in IESCO network
    3. Qualitative analysis providing an overview of international lessons of relevance for net metering and auctions in Pakistan

- **PV Ecosys**: Step Robotics, a Pakistan based technology start-up, is developing an online platform called PV Ecosys in collaboration with AEDB, to address several issues associated with the net metering application and installation process. The platform comprises four different modules, catering to various stakeholders (consumers, installers, NEPRA and the DISCOs etc.) and is expected to automate key processes associated with net metering, including vendor selection, quality verification for equipment, net metering license acquisition and several functions related to the DISCO. The platform also establishes one standard operating procedure (SOP) for DISCOs to process net metering applications. The developers expect to launch the net metering application function of the platform by December 2018, with three DISCOs integrated in the initial phase. Subsequent modules of the platform are expected to launch in 2019 with an eventual roll-out to all DISCOs and additional stakeholders.

5. RECOMMENDATIONS

5.1 ADDRESS POLICY, LEGAL AND REGULATORY ISSUES

1 - Pakistan's current RE policy lapsed in 2018 with no clear indication of whether net metering will receive policy cover under a new policy regime

Recommendation:

- The net metering policy framework should be embedded in a broader policy to encourage the development of renewable energy sources. This is particularly relevant for Pakistan due to the country's heavy reliance on imported fossil fuels for power generation. Increasing RE from distributed resources will lower the weighted-average bulk supply generation cost in the country, reduce the adverse environmental impact of conventional power generation and mobilize small-scale private investment in DG

2 – The current net metering regulations do not reflect the changes in the NEPRA Act that could benefit electricity customers with net-metering installations

Recommendations:

- Based on the NEPRA Act 2018, Section 14 B (5), net metered installations should be excluded from the mandatory generation license requirement. applicable under the current net metering regulations.
- Net metered generation facilities should not be restricted to sell surplus electricity to their host DISCO only.
- Cooperative housing societies and consumer associations generating power primarily for their own usage should be allowed to subscribe to the net metering program. as one net-metered entity.

3 - Net metering regulations are missing local-level caps, include no provisions for information sharing between the DISCOs and the regulator and allocate all equipment and interconnection costs to consumers

Recommendations:

- NEPRA should specify local caps on net metering, based on the capability of feeding system at the DT and distribution-grid level. Limit on grid-penetration at 30% of DT capacity is recommended in the first phase of net metering programs, especially where infrastructure upgrades might be required to accommodate high levels of DG penetration. A system assessment would need to be conducted by the regulator and DISCOs to arrive at a safe DT-level cap.
- The cost of bi-directional meters and interconnection should be borne by the host DISCO and recovered from the net metered consumer through a monthly charge applied to the consumer's electricity bill.
- The regulator should require all DISCOs to submit net metering subscription information to regulator on a monthly basis. The subscription report should include all relevant information, such as the number of net metered connections added to the DISCOs network, the units of electricity purchased from net metered installations and payments made against net-excess generation to net metered customers. Changes to NEPRA net metering regulations could include the following:

4 – The interconnection standards are ambiguous on several accounts

Recommendations for changes to NEPRA net metering regulations:

- Small distributed generators based on RE Renewable with a capacity of less than 500 kW, connecting to the distribution grid at a voltage lower than 11 kV should be included as a separate category in Schedule I of the Interconnection Regulations, 2018.
- The regulator should clarify whether simulation studies are required for systems smaller than 100kW and assign clear responsibility to either the DISCO or the net metered customer for carrying out these studies. ***Subject to system specific studies for each DISCO, the regulator could exempt smaller systems (10 kW or smaller) from simulation studies. NEPRA should carry-out a comprehensive assessment to identify net metered customers that are deemed safe for interconnection and can be connected to the grid without a system study.***
- Net metered customers connecting to a distribution network should be provided with the required interconnection facility by the host DISCO. The DISCO can then recover the cost of the interconnection as part of the DISCO's asset base. In case the interconnection assets fall in the customer's ownership, the DISCO should still pay for the cost upfront cost of interconnection and recover the expense from the net metered customer through commensurate charges added to the customer's monthly electricity bill. By providing all interconnection equipment, the DISCO can ensure quality conformity and avoid delays in interconnection.

5.2 DEVELOP AN IMPLEMENTATION PLAN

There is no clear implementation plan in place to guide net metering market roll-out

Recommendations:

- The Ministry of Energy should treat net metering as a provisional policy intervention, define clear objectives for the program and provide an implementation plan for market roll-out. The penetration level of DG should be the leading criteria for altering or terminating net metering programs. Penetration levels can be defined in terms of the cumulative capacity of net metered installations, as a percentage of a network's generation capacity or a percentage of peak-demand on a network. Once the distribution network achieves a pre-defined level of net metered installations, compensation for DG can be adjusted by transitioning from net metering to net-billing or with-drawing incentives entirely.
- An upfront review of technical and financial impacts of net metering on distribution companies should be conducted to identify and limit risks to distribution companies and investors. Technical impacts that need to be analyzed and quantified include the impact of DG on the quality of electricity supply, technical impacts on consumers without net metering and the potential for reverse power flow from the low-voltage to the medium-voltage network. The financial impact assessment should address the impact of net metering on DISCO revenues, the existing tariff subsidy regime and potential cross-subsidization by consumers without net metering installations.
- The impact of net metering regulations on the performance of the energy network should be assessed from both a short-term (operations) perspective and a long-term (network expansion) view. In the short-term for instance, net metering could relieve nodal-congestion and improve service quality. Long-term impacts include reduction in transmission investments by using net metered DG as an alternative to network augmentation.

5.3 ADDRESS MARKET BARRIERS

1 - High upfront cost of systems and limited access to debt

Although the LCOE of roof-top solar systems is significantly lower than grid-supplied electricity, net metered installations are capital intensive and require upfront investment in equipment, labor and permitting costs. The high upfront cost of the systems makes them un-affordable for most electricity consumers and inhibit growth in the net metering market, despite the potential for savings in electricity bills. Assisting local banks to increase financing to solar rooftop and other renewable DG installations will address a major barrier limiting the growth of net metering in Pakistan. Recommendations to address the lack of financing include:

- Provide training to financial institutions for developing consumer finance products for the small-scale DG market and improve the institutional capacity to process loans for net metered installations.
- Develop standardized tools to assess rooftop solar project risk and streamline the due-diligence of net metering loans.
- Involve DISCOs in PPAs between consumers and third-party installers and financing agreements between banks and net metering customers.

2 - Limited administrative capacity of the distribution companies

As the only power purchasers, distribution companies are a major stakeholder in the net metering market and impact every stage of the net metering application and installation process. The capacity of the DISCO to administer and manage net metering installations is therefore a key pre-requisite for market growth. DISCOs in Pakistan are managing the net metering program with varying degrees of success, however, progress in increasing the net metering uptake is slow overall and could benefit from capacity building at the distribution companies. Recommendation to alleviate this issue include:

- Automate key processes for installing and managing net metered systems (application, interconnection and billing etc.).
- Train DISCOs in financial/technical impact assessment.

3 - Resistance from some DISCOs

The distribution companies' concerns over revenue loss could be addressed through new business models involving DISCOs. For instance, DISCOs can participate in roof-top solar PPAs with third-party installers (assuming agency for credit collection or providing joint guarantees to financial institutions) or independently provide net metering installation services to their customer base.

4 – Complicated application and interconnection process

To simplify and expedite the process for installing net metered systems, key processes need to be simplified and expedited. This can include:

- Standardize SOPs across DISCOs
- Automate key processes related to net metering application, installation and interconnection.

5 - Consumers perception of technology and performance risk or a lack of awareness about the net metering program

Most electricity consumers are either unaware of the net metering program or consider the technology un-proven. AEDB has implemented several initiatives to reduce the risk perception around net metering systems; Installation companies are required to register with AEDB and only AEDB certified installers are authorized to set up net metering installations on a DISCOs network. In collaboration with GIZ, AEDB is also developing an installer verification scheme called PV passport. The availability of net metering and risk reducing initiatives by AEDB and others need to be publicized. A draft scope for a 'consumer-awareness campaign' to popularize net metering is included in **Annex 5**.

6 - Limitation on availability of roof-top space

Commercial net metering customers located in rented spaces or those requiring more space for rooftop generation than what is available at their own premises should have the option of wheeling electricity from a separate generation location (either their own or maintained by a third-party provider) under a net metered arrangement. Although the NEPRA Act 2018 makes provisions for wheeling and NEPRA has issued regulations to develop the wheeling market, DISCOs are generally reluctant to support business models around wheeling.

Table 5.1: Developing the Net Metering Market in Pakistan -Summary Recommendations

	Issue	Recommendations	Key Stakeholders	Existing interventions
1	Lack of policy cover	• Include net metering in the new energy policy	MOE, AEDB	None
2	Inconsistency of the policy with the NEPRA Act 2018	• Exempt net metering installations from generation licenses • Allow sale of surplus electricity to any DISCO • Allow net metering to cooperative housing societies and consumer associations generating captive power	MOE, NEPRA	None
3	Deficiencies in net metering regulations	• Conduct a system assessment to determine a suitable local-level cap • Assign the upfront cost of bi-directional meters and interconnection to the DISCOs (to be recovered from the net metered consumer through a monthly charge) • Require DISCOs to submit net metering subscription information to regulator on a monthly basis.	NEPRA	Pakistan DG road map (GIZ/AEDB) for assessing local-level caps None in other areas
4	Deficiencies in Interconnection standards	• Assign a separate category in the Interconnection Regulations to small generators connecting at a low voltage • Clarify responsibility for simulation studies • Assess feasibility of exempting small DG systems (10 kW or smaller) from simulation studies.	NEPRA	None
5	Lack of a net metering implementation plan	• Apply net-metering as a provisional policy intervention with clear objectives and an implementation plan • Perform an upfront review of technical and financial impacts of net metering on distribution companies • Assess the impacts of net metering on the energy network performance	Ministry of Energy, NEPRA, AEDB, DISCOs	Pakistan DG Roadmap (AEDB/GIZ)
6	High capital cost of system and limited access to debt	• Train financial institutions in processing small RE loans • Develop standardized tools to assess rooftop solar project risk	AEDB DISCOs	PV Passport (AEDB/GIZ)

Issue	Recommendations	Key Stakeholders	Existing interventions
	• Involve DISCOs in PPA between consumers and third-party installers	State Bank of Pakistan International Development Organizations Financial Institutions	
7 Limited administrative capacity of the distribution companies	• Train DISCOs in process implementation and financial/technical impact assessment • Process automation	AEDB, GIZ DISCOs Step Robotics	Pakistan DG Roadmap PV Ecosys (AEDB/Step Robotics)
8 Resistance from DISCOs	• Incentivize DISCOs through innovative business models involving DISCOs	DISCOs, NEPRA, AEDB	None
9 Lack of awareness about net metering among power consumers and consumers' perception of technology and performance risk	• Conduct an awareness-raising campaign	AEDB	None
10 Complicated process	• Standardize SOPs across DISCOs • Process automation	DISCOs, AEDB, Step Robotics	PV Ecosys (AEDB/Step Robotics)
11 Limited availability of rooftop space	• Develop business models around wheeling	Third party providers	None

ANNEX 1: COSTS AND BENEFITS OF DISTRIBUTED GENERATION[85]

Net metering is a policy mechanism for supporting the growth of renewable energy generation. The mechanism incentivizes consumers to produce renewable electricity on-site for their own consumption and selling back to the grid. Introduced in the US state of Minnesota and Iowa in the early 1980s, original Net metering policies provided compensation at retail rates for any electricity sold back to the grid. However, once penetration of distributed renewable energy generation in some jurisdictions reached a level where the economic and technological costs of net metering were no longer considered tenable, net metering policies saw a significant shift to lower compensation levels, increased fixed charges, Time-of-Use rates for electricity consumption and limits on power fed back into the grid. The list below describes the costs and benefits of net metering most frequently cited in academic and professional literature. Although net metering is a well-researched subject, a few important caveats should be considered;

- A cost-benefit analysis of net metering is a complex task that must quantify the impacts of net metering on the utility grid, electricity tariffs and various externalities that benefit society. Depending on the valuation approach and method, assessments are at times carried out under widely varying assumptions, resulting in inconsistent or conflicting outcomes.
- The benefits provided by distributed generation mechanisms (such as net metering) to the utility system can be very location specific and vary based on the period during which electricity is sold back to the grid, the demand profile of the producer, insolation levels at the point of generation and other factors.
- Most benefits attributed to net metering are not exclusive to these installations and can be derived equally and sometimes more effectively from other types of renewable energy installations (e.g. grid-scale RE generators).

85 PUC Sri Lanka, "*Net Metering Development in Sri Lanka*"; MIT, "*The Future of Solar Energy*"; Lynne Kiesling, "*Alternatives to Net Metering: A Pathway to Decentralized Electricity*", R Street Policy Studies 2016 (Washington, DC: R Street, February 2016); Deloitte, "*Rooftop Solar - Garnering Support from Distribution Utilities*" (India: Deloitte Touche Tohmatsu India LLP, December 2016); Michael Barnard, "*The Net Metering Disconnect*", CleanTechnica, January 2016, www.cleantechnica.com; Robert E. Curry, "The Law of Unintended Consequences", *Public Utilities Fortnightly*, March 2013, www.fortnightly.com; MEI, "*Net Metering in Missouri: The Benefits and the Costs*" (Missouri Energy Initiative, 2015); Julia Pyper, "*Ditching Net Metering Is in the 'Best Interest' of Solar, Say MIT Economists*", May 5, 2015, https://www.greentechmedia.com/articles/read/mit-economists-say-we-should-ditch-net-metering; Rickerson et al., "*Residential Prosumers - Drivers and Policy Options*"; Metin Celebi and Philip Q. Hanser, "*Marginal Cost Analysis in Evolving Power Markets: The Foundation of Innovative Pricing, Energy Efficiency Programs, and Net Metering Rates*", Newsletter, Current Topics in Energy Markets & Regulation (Brattle Group, 2010); Michael G. Pollitt and Wadim Strielkowski, "*Consumer Solar Distributed Generation (DG): Net Metering and Some Competition Issues*" (University of Cambridge, Energy Policy Research Group, August 2016).

Benefits	Costs
Technical Impact	
Grid management benefits *Voltage and Frequency Regulations* - By encouraging electricity generation near the point of consumption, net metering reduces the strain on distribution systems, maintains the stability of grid frequency and improves the distribution voltage profile. *Peak Load Management* - Net peak-loads can be reduced if peak-demand is coincident with net metered power generation. Coordinating net metered generation with energy storage and techniques of demand management can also contribute to peak load management. *Grid Efficiency and Reliability* - Energy generation closer to the point of consumption improves grid efficiency and reliability and reduces consumption issues.	**Grid Management issues** *Grid Balancing* - Solar installations can create issues for balancing loads if the quantity of installations does not match the size of the local service transformer. Grid balancing is especially problematic in developing countries with weak and inadequate transmission and distribution equipment. *Incompatibility with grid architecture* - The grid is not designed to cope with complications arising from intermittent renewable energy resources. Intermittent, distributed generation in particular, affects power flow patterns in the grid, causing various well-documented (and predominantly local) problems that may require significant network upgrades and modifications. Many countries with high levels of renewables in their energy mix regularly curtail energy from renewable generators to avoid over-loading the grid. High levels of distributed generation will require modernization of the existing distribution system, which was designed, built, and operated for centralized generation.
Energy-banking Net metering maximizes the utility of rooftop PV systems that do not have storage batteries installed. Consumers can 'bank' surplus energy on the grid to off-set metered supply.	
Impact on land-use constraints Land-constraints for diffuse natural resources such as solar and wind pose a major barrier to scaling energy generation from these resources. This is a particular barrier to large-scale deployment in densely-populated, developing countries where land availability is limited, or ownership is not clearly defined. In such situations, roof-top solar can off-set domestic gas consumption with positive effects on the economy.	
Capacity building at utilities New technology is driving innovative models of electricity generation and consumption and future developments in the sector (improvements in storage solutions for instance) can have a critical impact on the current utility business model. Policies such as net metering provide utilities with the opportunity to gain insight into new energy generation technologies and acquire expertise in accommodating and managing energy from un-conventional resources.	

Benefits	Costs
Financial and Economic Impact	
Financial Benefits to Utilities *Avoided energy cost* - By reducing overall demand for electricity, net metering helps utilities avoid the cost of purchasing or generating energy to meet electricity demand. *Avoided capacity and transmission infrastructure investment* – Reduction in overall demand and on-site generation through net metering can translate into a reduced need for utilities to invest in capacity and transmission expansion. *Reduced transmission losses* – On-site generation reduces transmission and distribution losses. Energy lost in generation, long-distance transmission and distribution can amount to a significant cost.	**Costs to Utilities** *Reduced revenue and profits* – In the absence of revenue decoupling regulations, an overall reduction in electricity demand would decrease utility revenues. In addition, net metering causes the utility to lose their most profitable customers; Most developing countries electricity rates for low income consumers are kept artificially low. Rates for domestic consumers are set in inclining blocks where high-income consumers using more electricity pay higher rates to cross subsidize low income consumers. Since net metering installations are relatively expensive, high income consumers are most likely to subscribe to the service and in the process, reduce their electricity consumption and the revenue they provide to utilities. *Under-recovery of grid costs* – In addition to the cost of energy, retail electricity rates include the cost of transmission, distribution and the utility's cost of providing electric service; cost of maintaining the grid, administration costs and other infrastructure costs that ensure grid safety and reliability. Net metering at retail rates allows net metered customers to avoid paying these largely fixed grid costs. Under-recovery has the potential to materially weaken the utility's financial integrity and its ability to attract investor capital, which in turn can lead to higher rates. *Increased System Operation Costs* - Even if the customer's total energy production over a billing cycle nets out its consumption over that time, the customer is still using grid services during that period. Utilities incur significant costs in providing these services: • Balancing costs: Utilities incur additional costs to integrate renewable generation resources, such as roof-top solar, if grid balancing facilities are not adequate to mitigate the impact of intermittent renewables in the system. The Law of Unintended Consequences Energy flows on the grid from distributed locations can be absorbed and balanced if the distributed generation resources are a small enough proportion of the energy portfolio. Balancing is harder and more expensive as that proportion rises. Balancing the network is the main operational cost that varies as the share of distributed generation on the grid changes. • Back-up capacity costs: The intermittency of renewable energy resources such as solar implies that a kW or solar cannot displace a kW of conventional power; in the absence of storage, some conventional back-up power will always be required on systems with intermittent renewable energy resources. • Cycling costs: The cost-reducing effects of increased renewable generation is partly counterbalanced by an increased need to cycle existing thermal plants as renewable energy output varies, reducing their efficiency and increasing wear and tear. The cost impact of this secondary effect depends on the existing generation mix: it is less

Benefits	Costs
	acute if the system includes sufficient gas-fired combustion turbines or other units with the flexibility to accommodate the 'ramping' required by fluctuations in solar output. At high levels of solar penetration, it may even be necessary to curtail production from solar facilities to reduce cycling of thermal power plants. Thus, regulations that mandate the dispatch of solar generation, or a large buildout of distributed renewable energy capacity that cannot be curtailed, can lead to increased system operating costs and even to problems with maintaining system reliability. There are also limits on the rate at which the output from thermal plants can be increased. In contrast, output from some renewable technologies, particularly PV and wind, can be varied without incurring additional costs. A requirement that renewable energy sources always have priority thus implies that costs associated with changing the output levels of conventional generating plants must be ignored in dispatch decisions. *Interconnection Costs* - Interconnection costs are incurred to link net metering installations to existing distribution systems in a way that ensures safety and reliability. These include capital costs related to service connections; circuit breakers to disconnect net metering installations when needed to protect utility workers and first responders; distribution circuits and substation upgrades; as well as metering, sensors, controls, and communication infrastructure needed to accommodate the increasing amount of two-way power flows on the distribution network. *Costs from increased losses at very high levels of DG penetration* - Although it seems reasonable to expect that generating electricity close to loads brings energy losses down and requires less network infrastructure to carry energy from other regions, these benefits are not realized in situations where distributed generators are not controllable; where mismatches exist between load and generation, both in terms of location and time; and where networks continue to be managed in the usual way. Costs from such losses have a general tendency to decline as the share of PV energy in a distribution network increases up to nearly 25%. At very high levels of PV penetration, losses start to increase.
Investment Displacement Net metering schemes generating clean energy can reduce the need for investment in expensive, polluting conventional power plants. The savings from displacing conventional power plants can be significant if net metered electricity is coincident with grid peak loads or expensive conventional power (from diesel generators for instance) can be displaced.	**Costs to Consumers** *Increase in the price of electricity* - In most jurisdictions, the compensation for net metered power sold back into the grid is higher than the cost of competing electricity production, usually from utilities or from the spot power market. Accordingly, higher cost net metered electricity is substituted in place of less costly electricity and overall power prices are forced above the level that would prevail in the absence of the net metering system. The combination of the installation subsidies and the excessive prices paid for power fed into the grid maintains an upward pressure on prices as net metering deployment increases and more expensive power is fed into the grid.

Benefits	Costs
	Cross-subsidization effects - Once net metered costumers increase in number, they begin to have impacts on rate design (cost sharing). Net metered customers avoid some portion of their fair share of fixed costs which must be paid whether they are actively using the grid or not. These costs are then re-distributed by the utility amongst all rate-payers which means that customers without net metering are in effect cross-subsidizing customers with net metering. Net metering is 'doubly regressive'— first by effectively excluding some customers from net metering because of its high initial cost, including lease and credit requirements; second by instituting a regressive wealth transfer from lower income customers to higher-income customers through cost-subsidization.
Private Investment in Renewable Energy Net metering can encourage electricity consumers to spend their own money to set up renewable energy systems.	**Increased Cost of the Energy Transition** Utility-scale solar is inherently less expensive than residential-scale and is likely to remain less expensive despite foreseeable cost reductions in residential. If avoiding harmful emissions this is the key purpose of policies such as net metering, it is uneconomical to promote rooftop and community solar as a most favored form of renewable and clean energy. Subsidizing residential-scale solar generation more heavily than utility-scale solar generation will yield less solar generation (and thus less emissions reductions) per dollar of subsidy than if all forms of solar generation were equally subsidized.
Consumer Rate Reduction *Price reduction due to decline in demand* - By reducing demand from the grid, net metering systems reduce the price of electricity, decreasing costs for all ratepayers. *Price reduction due to fuel displacement* **–** In jurisdictions where renewable, electricity generated on-site is cheaper than energy from conventional power plants, renewable energy brings down the average cost of electricity.	**Additional Subsidy Requirement** Residential net metering installations are generally not economically viable without additional subsidies or financial incentives because residential roof-top solar hasn't achieved grid parity in some parts of the world. In addition, conventional definitions of grid-parity do not account for social and private costs of grid reinforcement and storage, often required to accommodate self-consumption. If these costs are considered, the point at which self-consumption from roof-top solar or other distributed generation facilities becomes competitive with grid supplied electricity, will be pushed back further.
Market Transformation Net metering encourages the growth of business models necessary to provide new energy services to consumers and in the process, creates a market for renewable energy products and services. Deployment of net metering even at a modest scale, is likely to reduce institutional and other barriers to a rapid scale-up of solar generation in the future while also stimulating industrial efforts to reduce costs and improve performance.	**Import Costs** Most developing countries rely on imported equipment for net metering installations. Large-scale deployment of net metering systems would impose an increase in import costs.

Benefits	Costs
Social Impact	
Energy Independence Contributes to the diversification of a country's energy portfolio and helps improve energy security by displacing imported fuel with an indigenous resource.	**Increase in Conventional Effluents** To avoid interruption in electricity supply, intermittent renewable energy generation requires backup generation capacity provided by conventional units usually powered by coal or natural gas. The backup facilities must be cycled up and down depending on sunlight (and wind) conditions in the various regional markets. Such cycling of conventional units means that they cannot be operated efficiently, the result of which is an increase in the output of conventional effluents and greenhouse gases per MWh generated. The cycling problem is sufficiently severe that it yields an increase in the absolute amount (not merely the amount per MWh) of conventional effluents and greenhouse gases emitted as the market share of renewables rises.
Pollution Reduction Global greenhouse gas emissions drive climate change. Widespread international adoption of new, non-emitting technologies will help phase out polluting, fossil fuel-based plants and deliver substantial public benefit. Production of energy from these sources often satisfies environmental regulatory requirements such as RPS requirements for utilities, and any future greenhouse gas emission reduction requirements from a carbon-tax or a cap-and-trade scheme.	**Pollution from Production Processes** Unless production of renewable energy equipment, especially solar panels, is shifted to countries with more stringent environmental standards, renewable energy can be expected to substitute one set of environmental effects with another.
	Impact on 'Public Goods' Programs Regulatory public goods programs, such as low-income assistance or subsidies are included in retail rates and are not recovered when net metered customers are reimbursed at the retail rate.
	Interaction with Pricing Principles Net metering runs counter to the principles of network pricing; Wealthier consumers, who can afford to install net metering facilities and who make more use of the network (by both buying and selling electricity through the network) make less of a contribution to the costs of the network. Net metering also conflates two issues that can be logically separated: (1) the desire of society to pay extra for certain types of distributed generation on the grounds of reaching renewable and decarbonization targets; and (2) public utility pricing principles for the recovery of network costs, which balance fairness and efficiency in network pricing.

ANNEX 2: COMPARISON OF METERING & BILLING ARRANGEMENTS[86]

M&B Arrangement	Description	Advantages	Disadvantages
Net Metering	Original net metering policies applied standard retail-rate to a customer's 'net' electricity purchases. A single, bi-directional meter could run backward and erase electricity consumption with electricity generated from the NM installation. Electricity production and consumption is 'netted' over a pre-defined period (year/month/day/ hour).	• Relatively simple mechanism for both DG system owners and DISCOs to understand and implement, especially for users that already have two-way meters installed, that can run backwards when surplus electricity is fed back into the grid. • Savings on electricity bills for consumers with net metered installations. • Net metering schemes are attractive where electricity tariffs are high. • Does not require significant regulatory changes; can easily be incorporated on top of existing retail electricity rates.	• Since net metering is compensated at retail rates, customers with net metered installations do not pay for the DISCO's full cost-of–service (net metering under-states cost-of-service). • Does not reflect the value of the DG electricity to the DISCO • Because it requires self-consumption of electricity prior to export, net metering can lead to reduced DISCO sales (unless the DISCO can sell the same electricity to a new consumer). • DISCOs may suffer revenue sufficiency issues if the retail rate paid to customers for excess generation is higher than the actual DG value. This challenge is negligible at low levels of DG adoption but may materialize as adoption levels increase. • Non-DG-system owners may experience retail rate increases if DG deployment increases DISCO costs and/or reduces DISCO electricity sales. Again, this may be negligible at low levels of DG adoption.
Buy-all Sell-all (BASA)	A buy-all, sell-all arrangement offers a standard sell rate to a DG system owner for *all* of the DG electricity they generate. Unlike net metering, buy-all, sell-all customers do not physically consume the electricity their DG systems produce. The level at which the sell rate is set	• Buy-all, sell-all mechanisms provide simple and predictable value propositions to both DG system owners and DISCOs over an agreed-upon contract length.	• If the value of DG is not well understood, buy-all, sell-all mechanisms can potentially over-or undercompensate DG system owners, leading to cost-shifting if buy-all, sell-all program costs are higher than whole-sale

[86] Sakr et al., "*Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt*"; Zinaman et al., "*Grid-Connected Distributed Generation: Compensation Mechanism Basics*"; J. Heeter, R. Gelman, and L. Bird, "*Status of Net Metering: Assessing the Potential to Reach Program Caps*" (National Renewable Energy Laboratory, September 2014); Weimar et al., "*Integrating Renewable Generation into Grid Operations*."

M&B Arrangement	Description	Advantages	Disadvantages
	will influence the value proposition for the customer, which will impact DG deployment level.	• Because buy-all, sell-all mechanisms do not change customer electricity consumption patterns, there is less of an incentive for DISCOs to attempt to recover costs through additional fixed charges. • Cross-subsidization issues are also minimized for this reason. • Buy-all, sell-all mechanisms do not require retail rate redesign. • Buy-all, sell-all prices can be adjusted throughout the lifetime of a program for new customers to steer the market toward the desired level of DG deployment.	electricity rates and fully passed through to the consumer. • If a buy-all, sell-all mechanisms rate is lower than the retail rate (a very common practice), customers may be incentivized to illegally wire their DG system to self-consume electricity instead of exporting it all to the utility grid, potentially leading to traditional revenue sufficiency and cross-subsidization issues. • High 'feed in' or 'value of solar' credits needed to provide adequate economic payback.
Net Billing	**Economical compensation** of your PV **electricity production value over your consumption value** during a pre-defined period of time. In net billing, a DG system owner can consume electricity generated by their DG system in real time and export any generation in excess of on-site consumption to the utility grid. In this way, net billing is similar to net metering, however, under net billing, energy banking is not allowed and all energy exports to the grid are compensated at a pre-determined sell rate as soon as the export is recorded. Neither the net electricity export meter nor the net electricity consumption meter have the ability to 'spin backward' during a billing cycle under net billing—the meters can only spin forward when measuring net consumption and net exports in real time. These quantities are measured in real time and billed/credited separately at the end of the billing cycle.	• Net billing allows for a more precise approach to compensating electricity being injected into the grid relative to NM because the sell rate for exported electricity can be set to match the value to the utility. Net billing can encourage self-consumption (particularly by setting sell rates as less than retail rates), if desired by regulators and policymakers NREL compensation mechanism basics	• Because net billing requires self-consumption of electricity prior to export, it can lead to lost DISCO sales. • DISCOs may suffer revenue sufficiency issues if the net export rate paid to customers for excess generation is higher than the actual DG value. This challenge is negligible at low levels of distributed generation penetration but may materialize as penetration levels increase.

ANNEX 3: EVOLUTION IN NET METERING AND FIT PROGRAM DESIGN

3.1 ORIGINAL NET METERING

Net metering is a Metering and Billing (M&B) arrangement where compensation is always at the retail rate i.e. the meter spins backwards when the DG system is supplying energy to the grid, erasing a part of the customers energy bill.[87] Net metering schemes are attractive in countries where electricity tariffs are high and are a relatively easy policy to administer, especially if users already have two-way meters installed.[88] A two-way or bi-directional meter runs backwards when surplus electricity is fed back into the grid.

Figure 1: Evolution of Net Metering and Feed-in-Tariffs
(Adapted from multiple sources) [89]

Original Net Metering	Original FIT
Originated in Massachusetts and Wisconsin in 1982 and currently offered in its original form in 38 US states and Washington DC. Compensation is at retail rate (meter runs backwards).	Germany (1991) and Denmark (1992) were the first two countries to implement a FIT. Compensation was at above Retail rates under a buy-all, sell-all (gross-metering) M&B arrangement
Evolution of Net metering	**Evolution of Feed-in-Tariffs**
Step down from retail to wholesale rates (Nevada, Maine, Indiana), application of demand charges (Arizona), Increased fixed charges or minimum bill (Hawaii, Texas) and Value-of-solar rates (Minnesota)	FIT offered with both buy all-sell all and net-billing. Compensation at or below retail rates (Australia, 2013, 2016, Germany), third party owned systems only (India), self-consumption allowed. The current German FIT is offered through a net-billing mechanism.

Current Net metering and FIT Schemes
The distinction between net metering, net billing and FIT schemes has blurred in recent years. Most so-called net metering schemes outside the US are net-billing mechanisms in practice.

87 Owen Zinaman et al., "Grid-Connected Distributed Generation: Compensation Mechanism Basics" (National Renewable Energy Laboratory (NREL), October 2017).

88 Patrick Curran and Gerrit W. Clarke, "Review of Net Metering Practices" (Namibia: Electricity Control Board of Namibia, December 2012).

89 Dalia Sakr et al., "Scaling Up Distributed Solar in Emerging Markets: The Case of the Arab Republic of Egypt," Policy Research Working Paper (Washington, D.C.: World Bank, June 2017); Julie Baldwin et al., "Report on the MPSC Staff Study to Develop a Cost of Service-Based Distributed Generation Program Tariff" (Michigan: MICHIGAN PUBLIC SERVICE COMMISSION, February 2018); Travis Lowder et al., "Historical and Current U.S. Strategies for Boosting Distributed Generation" (Colorado, USA, August 2015).

3.2 ORIGINAL FEED-IN-TARIFFS (FITS)

A FIT is defined as a predetermined level of compensation (usually above the retail rate) for electricity fed into the grid from a distributed energy system. Customers receiving FITs are often (but not always) required to sell all their on-site electricity production to the grid i.e. self-consumption is not allowed. Unlike net metering, a FIT is not an M&B arrangement although the term FIT is used interchangeably with gross-billing (Buy all-Sell all) arrangements.[90]

Net metering (aM &B arrangement) and FIT (a predetermined Sell-Rate) are components of a compensation scheme but do not constitute a compensation mechanism in its entirety. The sell rate design and retail rate design are equally important in the design of compensation schemes.

3.3 THE EVOLUTION OF NET METERING AND FITS

The distinctions between traditional policy labels such as FITs, auctions, and Net metering are increasingly hard to discern as policymakers adapt frameworks to new market realities. New policy frameworks use a mix of net metering, FITs and auctions to provide targeted support to DG across specific market segments

Starting in the early 2000s, France instituted a FIT scheme for some renewable energy technologies, while procuring others such as biomass and offshore wind through tenders. The following year, the use of tenders was extended to smaller projects; A 'simplified' tender was introduced for projects between 100 kW and 250 kW and a more 'complex' one projects between 250 kW and 12 MW. Systems below 100 kW remained eligible for fixed FIT rates. Based on tendering results in 2013, the average weighted purchase price of tendered projects between 100 and 250 kW was significantly higher than the tariffs offered to smaller projects (0–100 kW) under the FIT. These results from France run counter to the conventional argument in favor of tendering as a means to securing lower prices.

Some Caribbean countries have adopted hybrid Net metering and feed-in policies allowing residential consumers to offset their power consumption while commercial consumers are required to feed all the power they produce into the grid. In the Cayman Islands, DG customers can choose to connect in front of the meter (as under a traditional FIT) or behind the meter (with Net metering). Under both configurations, generators are billed at the retail rate for all the power that is consumed on-site. This arrangement applies whether that electricity is purchased from the grid or generated by the on-site PV system. Electricity generated by the PV system is then compensated at a rate of ~$0.47/kWh for residential systems for a 20-year period, whether or not that power is consumed on-site or exported directly into the grid. For comparison, the residential retail rate was USD $0.44/kWh in the first quarter of 2014.[91]

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90 Zinaman et al., "Grid-Connected Distributed Generation: Compensation Mechanism Basics."

91 T. D. Couture et al., "Next Generation of Renewable Electricity Policy: How Rapid Change Is Breaking Down Conventional Policy Categories" (National Renewable Energy Lab. (NREL), Golden, CO (United States), February 1, 2015), https://doi.org/10.2172/1172282.

ANNEX 4: FINANCIAL MODEL ASSUMPTIONS FOR NET METERED SOLAR PV SYSTEMS

The simulations were run using the SANDIA Labs simulation engine and the system generation or production numbers are within 1% of the production numbers from the Solar GIS atlas for Pakistan.

Assumptions in the financial model include a real discount rate of 10%, all capital costs are paid for by the customer (capital investment is unleveraged) and the system does not include storage batteries.

The simulation assumes an energy settlement only and does not account for any commercial settlement (cash compensation) for Net Excess Generation (NEG)

LCOE levelized over 25 years.

A corporate tax rate of 35% is applied to the commercial and residential financial models.

The equipment specifications in the financial model are based on mono-silicon solar panels manufactured by Yingli Energy; Model no. YI270 D-30B.

The orientation of the panels is 180 degrees due south.

Residential System		
System size	5.4 kW	
Capital cost (per kW)	PKR 105,000 (USD 751)	
Annual system production	7819 kWh	
Customer's annual electricity consumption	8700 kWh	
Applicable tariff rate (per kWh)	Peak; PKR 24 (USD 0.17) Off-peak: PKR 17.5 (USD 12.5)	
Inflation rate	8 %	
Real Discount rate	10%	
Location	Islamabad, Pakistan	
Capacity factor of the solar system	16.5 %	
Payback period	Simple: 3.8 years	Discounted: 5.2 years
LCOE	Real: PKR 8.7 (USD 0.06)	Nominal: PKR 14.48 (USD 1.04)

Commercial System		
System size	43 kW	
Capital cost (per kW)	PKR 85,000 (USD 608)	
Annual system production	63711 kWh	
Customer's annual electricity consumption	73200 kWh	
Applicable tariff rate (per kWh)	Peak; PKR 25 (USD 0.17) Off-peak: PKR 25 (USD 0.17)	
Inflation rate	8 %	
Real Discount rate	10%	
Location	Islamabad, Pakistan	
Capacity factor of the solar system	16.5 %	
Payback period	Simple: 3 years	Discounted: 3.7 years
LCOE	Real: PKR 5.76 (USD 0.04)	Nominal: PKR 9.85 (USD 0.07)

Industrial System		
System size	1 MW	
Capital cost (per kW)	PKR 80,000 (USD 572)	
Annual system production	1,433,506 kWh	
Customer's annual electricity consumption	1,550,410 kWh	
Applicable tariff rate (per kWh)	Peak; PKR 25 (USD 0) Off-peak: PKR 17.5 (USD)	
Inflation rate	8 %	
Real Discount rate	10%	
Location	Islamabad, Pakistan	
Capacity factor of the solar system	16.5 %	
Payback period	Simple: 3.8 years	Discounted: 5.2 years
LCOE	Real: PKR 5.48 (USD 0.04)	Nominal: PKR 9.38 (USD 0.07)

ANNEX 5: DRAFT SCOPE FOR A NET METERING PUBLIC AWARENESS CAMPAIGN

Introduction: There is a need to develop a public awareness campaign on net metering (NM) to explain the underlying issues and concerns and highlight the benefits to the suppliers and the utilities in general and the country in particular. This section provides a brief outline of such a campaign, which would need to be developed by professional Public Relations/Communication firms. Given how campaigns attract the attention of general population, it is proposed to adopt a slogan such as "Let Us Make Renewable Energy Power the Economy" or "Renewable Energy for Sustainable Development in Pakistan".

Objectives: The objectives of the campaign are envisaged as follows:

- To improve knowledge and understanding of distributed generation and renewable energy (RE) technologies, integration to the grid, and net metering among the target audience.
- To allay misperceptions about net metering among the utilities regarding the adverse financial consequences and present experience from other developing economies.
- To improve public understanding of the principles and need for energy efficiency, and substitution of fossil-fuel plants with RE generation in a sustainable manner.
- To create awareness and support for Government's vision of transitioning towards renewable energy in the power sector and achieving clean energy targets.
- To generally create a conducive environment for achievement of renewable energy and net metering targets in Pakistan.

Target audience: The beneficiary of this awareness campaign would be varied and there would be value in segmenting the target audiences in homogeneous groups to convey the messages clearly. Following stakeholders are among the target audience:

- Policymakers and regulators – technical, financial, commercial, legal and regulatory professionals would be key to the establishment of appropriate enabling framework for RE and net metering.
- Utility officials – technical, financial and commercial professionals who are responsible for network operations, interconnection and metering, financial management, and performance monitoring and control.
- Private industrial and commercial investors / associations – investors keen on setting up captive generation and supplying surplus units to the grid may be identified (Small- and Medium Enterprises; textile industry; large commercial establishments; etc.).
- Large residential customers – select group of residential customers with the ability to invest in decent-sized solar PV systems for alternative source of electricity.
- General public and stakeholders – representatives of consumer associations, civil society organizations, youth, environment NGOs, community organizations, and cooperatives.
- Media representatives - print and electronic.

Key messages for the campaign: It would be helpful to prepare key messages to be delivered to the target audience on adopting renewable energy technologies and net metering in Pakistan. While the specific messages would be delivered by the specialist firm, following messages could be considered:

- Net metering is a win-win proposition for all
- Generates employment at the grassroot level through distributed generation
- Supports renewable energy and reduces the cost of electricity in Pakistan.
- Saves money on electricity generation and supply and gives a competitive edge to the industry and businesses in Pakistan
- Reduces global warming by limiting the use of fossil fuel plants and improves public health.
- Creates green jobs and promote independence of imported energy supplies

Proposed content of the awareness campaign: The following is an illustrative list of topics and concepts to be shared with the target audience in an appropriate format (narrative, pictorial and visual etc.).

- Economics of net metering and distributed generation installations
- Solar electricity, water heating, and other end-uses
- Basics of other RE sources (mini- and micro-hydro, wind, biomass)
- Energy efficiency tips (buildings and homes, appliances, lighting, etc.)